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NZS 5826 (2010) (English): Pool water quality [By Authority of New Zealand Ministry of Education Health and Safety Code of Practice]

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NZS 5826:2010

New Zealand Standard

Pool Water Quality

Superseding NZS 5826:2000

NZS 5826:2010

COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the P 5826 Committee the Standards Council established under the Standards Act 1988.

The committee consisted of representatives of the following:

Nominating Organisation

Community Leisure Management
Institution of Professional Engineers New Zealand
Institute of Environmental Science & Research Ltd
Local Government New Zealand
Ministry of Education
Ministry of Health
New Zealand Chemical Industry Council Inc.
New Zealand Master Pool Builders Incorporated
New Zealand Principals' Federation
New Zealand Recreation Association
Water New Zealand
Water Safety New Zealand

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Standards New Zealand gratefully acknowledges the contribution of time and expertise from all those involved in developing this Standard.

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REFERENCED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARD

NZS 4441:2008	Swimming pool design Standard

JOINT AUSTRALIAN/NEW ZEALAND STANDARDS

AS/NZS 2927:2001	The storage and handling of liquefied chlorine gas
AS/NZS ISO 31000: 2009	Risk management – Principles and guidelines
AS/NZS 4276:- - - -	Water microbiology

AUSTRALIAN STANDARD

AS 3633:1989	Private swimming pools – Water quality

INTERNATIONAL STANDARD

ISO/IEC 31010:2009	Risk management – Risk assessment techniques

OTHER PUBLICATIONS

American Public Health Association (APHA): *Standard methods for the examination of water and wastewater*, 21st edition.

Korich D G, Mead J R, Madore M S, Sinclair N A, Sterling C R. 'Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocyst viability'. *Applied Environmental Microbiology* 1990 May; 56(5): 1423–1428.

Ministry of Health. *Drinking-water standards for New Zealand 2005* (revised 2008).

World Health Organization: *Guidelines for safe recreational waters* Volume 2 – *Swimming pools and similar recreational-water environments*, 2006, ISBN 92-4-154680-8

NEW ZEALAND LEGISLATION

Local Government Act 2002
Hazardous Substances and New Organisms (HSNO) Act 1996
Health and Safety in Employment (HSE) Act 2005

RELATED DOCUMENT

Although not referenced in this Standard the following document also contains helpful information:

United States Environmental Protection Agency (USEPA): National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule: Final Rule. http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-05/w04b.pdf

WEBSITES

http://www.legislation.govt.nz
http://www.erma.govt.nz
http://www.osh.dol.govt.nz

LATEST REVISIONS

The users of this Standard should ensure that their copies of the above-mentioned New Zealand Standards are the latest revisions. Amendments to referenced New Zealand and Joint Australian/New Zealand Standards can be found on http://www.standards.co.nz

REVIEW OF STANDARDS

Suggestions for improvement of this Standard will be welcomed. They should be sent to the Chief Executive, Standards New Zealand, Private Bag 2439, Wellington 6140.

FOREWORD

This New Zealand Standard was prepared by the Standards New Zealand Technical Committee P 5826 Pool Water Quality, at the request of Local Government New Zealand, to update NZS 5826:2000 *Pool water quality.*

As an important public health Standard, this edition has been substantially revised and updated to reflect current knowledge, technology, and processes. This Standard is intended to be used by all pool owners and pool managers, and consists of two Parts:

(a) Part 1 contains water quality parameters to meet in order to claim compliance with the Standard;

(b) Part 2 incorporates a major change with the provision of guidance on the application of risk management principles to water quality and general pool management. This material may be used by a pool owner or pool manager to prepare a tailored pool risk management plan (PRMP), which will identify potential harmful events impacting on water quality, and indicate solutions.

The requirement in the Standard that pools have water quality risk management plans in operation is new. All public pools shall have risk management plans in place, and domestic pool owners should operate their pools in accordance with these principles.

Risk management plans ensure that swimming pools are operated as safely as possible, in order that the largest possible number of users benefits from these recreational water environments. Risk management principles and plans will be helpful to all pool owners and pool operators in understanding general pool management and maintenance, and should help pool managers ensure compliance and drive cost savings by taking all practicable steps, in proportion to the assessed risk, to eliminate, isolate, or minimise each risk to water quality.

Users of this Standard are reminded that it has no legal authority in its own right, but acquires legal standing when cited or referenced in legislation, or adopted by the Government or other authority having jurisdiction.

OUTCOME STATEMENT

This Standard will, through identification of all practicable steps, assist pool owners and pool managers to meet their responsibilities for public safety by providing robust and efficient pool water quality management systems that ensure that the water used in pools is maintained to safeguard health.

New Zealand Standard
Pool water quality

PART 1 POOL WATER QUALITY

1.1 Scope, objectives, and interpretation

1.1.1 Scope

NZS 5826 addresses the essential aspects of the operation and maintenance of pools with a focus on pool water quality criteria including methods of water treatment to ensure the risk to public health is minimised. NZS 5826 does not cover the maintenance of heating, mechanical, or electrical equipment used by pools. The design of swimming pools is covered by NZS 4441.

This Standard covers all treated public and private freshwater and seawater swimming pools, spa pools, and geothermal pools, during use.

1.1.2 Objectives

The purpose of this Standard is to ensure that:

(a) Chemical and microbiological levels are maintained to safeguard health;

(b) Water is aesthetically acceptable;

(c) Unnecessary discomfort is prevented;

(d) Degradation of the pool and associated equipment is minimised.

1.1.3 Interpretation

1.1.3.1

For the purposes of this Standard, the word ‘shall’ refers to requirements that are essential for compliance with the Standard, while the word ‘should’ refers to practices that are advised or recommended.

1.1.3.2

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix forms an integral part of the Standard. An ‘informative’ appendix is only for information and guidance.

1.2 Definitions and glossary of terms

For the purposes of this Standard the following definitions and glossary of terms shall apply.

1.2.1 Definitions

Term	Definition
Continuous automatic chemical residual controller	A continuous residual chlorine analyser containing integral temperature compensation and pH control that is coupled to the dosing system. Proof of regular calibration and servicing is required
Local authority	As defined in the Local Government Act, and includes territorial authorities and regional councils
Online monitoring	The process of measuring and recording a defined chemical or physical property by taking frequent measurements, using an electronic monitoring device specifically designed for the purpose
Pool	A water-retaining structure, wholly or partially of artificial construction and generally having a circulation and filtration system, designed for recreational, training or therapeutic use. This definition excludes baths of the domestic style which are used for personal hygiene and are emptied after each use, regardless of location
Pool, domestic	A pool located in the grounds of a private dwelling and intended to be used by members of the household and their invited guests
Pool, geothermal	A pool which uses geothermal water, that is, water that emerges from the ground at an uncontrolled temperature generated by geological forces. This includes recirculating systems and unfiltered, non-recirculating ('fill and draw') systems
Pool, public	A pool other than domestic. This category includes commercial, school, institutional, club, hospitality industry, community, and local authority pools
Pool, spa, and hot tub	A pool, with or without air jets, in which the user soaks in heated water (35 – 40°C)
Qualified person	A person, who has acquired through training, qualification, or experience or a combination of these, the knowledge and skill enabling that person to perform the required task correctly
Risk	The effect of uncertainty on objectives, as defined in AS/NZS ISO 31000

Risk management plan	A plan that: (a) Identifies the elements that make up the pool; (b) Identifies contamination controls that are in place; (c) Sets out a risk information table appropriate for the pool; (d) Includes an improvements schedule, which identifies the preventive measures that have yet to be put in place; prioritises the measures for attention based on the risk they present to health and the availability of resources to provide them; sets a date by which they should be put in place; and identifies who has responsibility for doing this; (e) Provides contingency plans applicable to the pool
Safety data sheet (SDS)	A form containing data on the properties of a particular substance and its associated emergency management procedures. Also referred to as a material safety data sheet or manufacturer's safety data sheet. See http://www.erma.govt.nz for more information
Technical supervision	In relation to any work, means that the work is undertaken under such control and direction of a qualified person to ensure that the work is performed correctly

1.2.2 Glossary of terms

Acid	A chemical compound that decreases the pH, for example hydrochloric acid
Alarm	A device that alerts the duty treatment plant operator in such a way that they can make an immediate response to address the problem that caused the alarm
Algae	Microscopic plants that grow in the presence of sunlight, moisture, and minerals. Large numbers of algae cause pool water to become discoloured, surfaces become slippery
Algicides	A disinfectant or chemical agent that can control the growth of algae
Alkali	A chemical compound that raises the pH, for example, sodium bicarbonate or sodium carbonate
Alkalinity	A measure of buffering capacity. A buffer limits the change in pH that occurs when pool water comes in contact with acidic or alkaline substances. The presence of bicarbonates gives pH the appropriate protection. Expressed as mg/L calcium carbonate ($CaCO_3$) equivalent
Backwash	Cleaning process for pool filters. Normally, water flow in the granular media filter is reversed and the dirty water produced is flushed to waste. The term is sometimes used to describe the process of cleaning pre-coat filters where treated water flow may not be reversed
Bacteria	Microscopic single-cell organisms that can be present in poorly treated pool water, some of which cause disease
Bactericide	A disinfectant which can inactivate *bacteria* in water
Breakpoint chlorination	The point at which the added dose of chlorine matches the organic content of pool water so that the maximum breakdown of organic matter occurs
Brine electrolysis	Nominal 1% solution of sodium hypochlorite produced by the electrolysis of brine

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Calcium hardness	See *Hardness*
Chloramines	Chlorine that has reacted with substances, generally containing nitrogen compounds (like urea), to form any one or more of the following: monochloramine, dichloramine, trichloramine (nitrogen trichloride). These three compounds are collectively known as combined available chlorine or CAC. Chloramines have a pungent chlorinous odour, bactericidal capability, poor oxidising capability, and cause irritation to eyes and respiratory system of pool users
Chlorine (Cl)	Chlorine is a common disinfectant. Chlorine compounds are often used in swimming pools to keep them clean and sanitary
Chlorine demand	A measure of the chlorine concentration required to oxidise the organic material present in the water
Chlorine residual	A general term which includes CAC, FAC, and TAC
Chlorate	An undesirable chemical by-product from the generation of chlorine dioxide
Chlorite	A chemical that is mixed with chlorine to create chlorine dioxide. Can be formed from the oxidisation of chlorine dioxide. An undesirable chemical by-product from the use of chlorine dioxide
Coagulation	The use of a chemical and physical process involving the addition of a coagulant/flocculant to aggregate fine suspended or colloidal particles, causing them to clump together into larger particles, thus assisting with their removal. See *Flocculation*
Coliform	Bacteria widely distributed in the environment and used to indicate that contamination of the water may have occurred by soil or other organic material, possibly faecal. The presence of coliforms indicates inadequate water treatment. Generally reported as colony-forming units per 100 millilitres (cfu/100 mL) or most probable number per 100 millilitres (MPN/100 mL) of sample. See *Faecal coliforms*
Colour comparison	Also known as colorimetric. Test methods involving the comparison of colours produced after chemical reagents are added to samples of water. The measurement can be by visual comparison or via Photometer
Colorimetric	See *Colour comparison*
Combined available chlorine (CAC)	Also known as combined chlorine residual (CCR) means the chlorine present as *chloramines* and other compounds which are formed when chlorine reacts with ammonia or organic nitrogen introduced into the pool. Can be determined by subtracting the results of a TAC test from that of a FAC test
Combined chlorine residual (CCR)	See *Combined available chlorine*
Conductivity	A measure of the electrical conductance of water. The level of electrical conductance is related to the level of total dissolved solids in water. Measured as mS/m at 25°C NOTE – 1 mS/m = 10 μmhos/cm and 1 μS/cm = 1 μmhos/cm.
Cryptosporidium	A flagellated member of the protozoa family. During its complex life cycle, thick walled oocysts are formed that are 4–6 μm in diameter. The oocysts are excreted in faeces and are the infectious form of the organism. *C. parvum* is the species responsible for most human infection. *Cryptosporidium* generally causes self-limiting diarrhoea, which may be accompanied by nausea, vomiting, and fever. In immuno-compromised people, infection can be life-threatening. It is highly resistant to chlorine

C.t values	The product of the concentration (C mg/L) of the disinfectant and the contact time (t minutes) required to cause a specified level of inactivation in a microorganism. C.t is a measure of the exposure to the disinfectant. It has the unit min.mg/L. The larger the figure the harder the organism is to kill
Cyanuric acid	A chemical which combines with chlorine to slow down the destructive effect of sunlight on chlorine
Dilution water	Water, usually from town water mains, used to replenish the pool after pool water is deliberately drained to waste to lower the total dissolved solids content or CAC level. Water which is added to a pool to replenish losses from causes such as splashing, filter backwashing is usually referred to as *Make-up water*
Disinfection	A process used to inactivate microorganisms in water
DPD	NN, diethyl–p-phenaline diamine sulphate; a laboratory chemical that reacts with chlorine to form a pink colour in the standard chlorine residual test
E. coli (Escherichia coli)	A subset of faecal coliform bacteria. Indicates that faecal contamination of the pool water has almost certainly occurred, and that there is a possibility that disease causing microorganisms are present. Measured as colony forming units per 100 millilitres of sample (cfu/100 mL) or the most probable number per 100 millilitres of sample (MPN/100 mL)
Ethylenediaminetetra-acetic acid (EDTA)	A colourless, water-soluble solid used to dissolve scale. A solution of known strength of this chemical is used in the hardness test
Element (pool water quality risk management)	Chemical or characteristic of pool water that is subject to change and therefore requires control. Recommended levels are set, and risk assessment is to be considered
Faecal coliform	A subset of coliforms, these bacteria are natural inhabitants of the lower gastrointestinal tract of warm blooded animals and are excreted in large numbers with faecal wastes. Their presence in pool water indicates that faecal contamination has probably occurred. Their presence in pool water also indicates poor water treatment, possible over-use of the pool and the possible presence of disease-causing bacteria. Measured as colony forming units per 100 millilitres of sample (cfu/100 mL) or most probable number per 100 millilitres of sample (MPN/100 mL)
Filtration	A physical process which strains suspended solids from water. Granular media and pre-coat filters are examples commonly used for public pools. Cartridge filter systems may be used for domestic pools only. Refer to NZS 4441
Flocculation	The gathering together of coagulated clumps of fine material to form floc or flakes. See *Coagulation*
Free available chlorine (FAC)	Also known as Free Chlorine Residual (FCR) means hypochlorous acid and hypochlorite ion in pool water. In these forms chlorine is said to be ‘free available’ because it is free or uncombined with other compounds and is available to immediately react with bacteria and contaminants introduced into the water. The ratio of hypochlorous acid to hypochlorite ion depends on the pH of the water. FAC is measured using a No. 1 DPD tablet, a DPD combined powder, or laboratory-prepared DPD indicator solution
Giardia	A flagellated member of the protozoa family. *Giardia* infects the gastrointestinal tract of humans and certain animals. Cysts are the infectious form of the organism excreted by the host; they are ovoid in shape, 8–12 µm. *G. intestinalis (lamblia)* is the species usually responsible for human infection. *Giardia* causes abdominal cramps and diarrhoea, which is self-limiting in most cases

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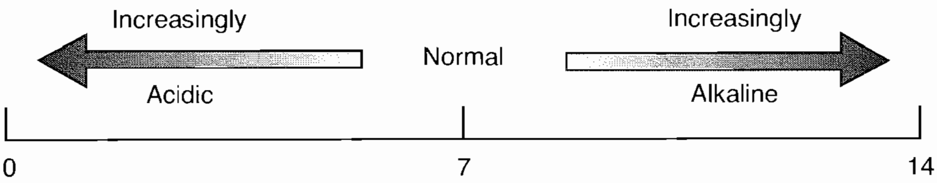
Hardness	The measure of calcium and magnesium compounds dissolved in water and expressed as mg/L calcium carbonate ($CaCO_3$) equivalent. Can be differentiated into total hardness and calcium hardness
Heterotrophic plate count (HPC)	See *Standard plate count*
Make-up water	See *Dilution water*
mg/L	Milligrams per litre, a measure of the concentration of substances in water. For example 3 mg/L of chlorine is 3 mg of chlorine in every litre of pool water. An equivalent measurement to g/m^3 (grams per cubic metre), $\mu g/mL$ (micrograms per millilitre), or parts per million (ppm)
Microorganisms	The group of microscopic creatures that include bacteria, viruses, algae, protozoa, and fungi
Nephelometric turbidity unit (NTU)	A measure of the degree of fine suspended material in a sample, which causes cloudiness in water. See *Turbidity*
Nitrogen trichloride	See *Chloramines*
Oxidation reduction potential (ORP)	ORP (oxidation reduction potential), a measure of the oxidising agents in the pool water measured in millivolts. Also known as Redox. Only ORP instrumentation that is based on symmetrical design with potential matching is suitable for this purpose
Particulates	A small solid particle of matter. Particulate material can remain suspended in water, where it is a contributor to poor water quality, unless physically removed
Pathogenic	Causes infectious disease or illness
pH	A measure of the concentration of hydrogen ions in water. It is the negative logarithm to base 10 of the concentration of H^+ in the water. A low pH indicates an acidic water; a high pH shows the water is alkaline; a pH of 7 is neutral. Measured on a scale ranging from 0 to 14  Increasingly Acidic Normal Increasingly Alkaline 0 7 14 NOTE – Since pH has a logarithmic basis, a solution with a pH of 5 is ten times more acidic than a solution with a pH of 6, while a solution with a pH of 4 is one hundred times more acidic than a solution with a pH of 6
Photometer	An instrument for measuring light intensity or optical properties of solutions or surfaces
pHs	The theoretical pH of a chemically balanced/saturated water as determined in the Saturation Index (Langelier Index) calculations for determining to what degree a water may be scale forming or corrosive
Pool bathing load	The number of pool users a pool is designed to cope with is based on the instantaneous bathing load. For example; for public pools, <1m deep = surface area ÷ 2.2, and if 1 – 1.5 m = surface area ÷ 2.7. Refer to NZS 4441
Pool turnover	The passage of the equivalent of the pool volume through the treatment system
Pre-coat filters	Treatment units that utilise a white porous powder as a filtration media for pool water treatment. For example, diatomaceous earth (DE)

Primary amoebic meningoencephalitis (PAM)	A potentially fatal disease caused by infections of the brain and meninges by the amoebic protozoa *Naegleria fowleri* and certain species of *Acanthamoeba*. These infections can occur if the pool user's head is immersed in contaminated water or from the immersion of any open wound in contaminated water. Potentially present in geothermal waters
Protozoa	A single celled *microorganism*, for example *Giardia*, *Cryptosporidium*
Pseudomonas aeruginosa	A bacterium that can grow in poorly treated or over-used pool water, often associated with spa pool infections, particularly of the skin. Measured as colony forming units per 100 millilitres of sample (cfu/100 mL) or most probable number per 100 millilitres of sample (MPN/100 mL)
Redox	Reduction – oxidation potential. See *Oxidation reduction potential*
Standard plate count (SPC)	Also known as heterotrophic plate count (HPC), total plate count, total aerobic plate count, or total viable plate count. A measure of the live bacteria that are present in a pool water sample and may indicate the possible presence of other microorganisms. The higher the number present, the poorer the water quality and its treatment. Measured as cfu/mL or colony forming units per millilitre of water
Saturation index (SI)	A measure for determining to what degree a water may be scale forming or corrosive. Also referred to as Langelier Index. See also *pHs*
Slug dose	Addition in one portion or shot over a relatively short period of time by metered delivery, rather than over an extended period of time
Staphylococcus aureus	A bacterial species often associated with eye, ear, throat, nose, and skin infections that can survive in poorly treated or over-used pool water. Measured as colony forming units per 100 millilitres of sample (cfu/100 mL) or most probable number per 100 millilitres of sample (MPN/100 mL)
Superchlorination	The practice of adding a single high concentration dose of chlorine to pool water to destroy chlorine-demanding compounds and to reduce combined chlorine. As a guide, add 10 times that of the CAC reading
Titration	A test method that dispenses a reagent of known strength via a burette into a sample of known volume to determine the concentration of a substance in a sample
Total chlorine	Also known as total available chlorine (TAC) means hypochlorous acid and hypochlorite ion (FAC) in pool water plus any combined available chlorine (CAC). TAC measured using a No. 4 DPD tablet or a No. 1 plus a No. 3 DPD tablet or DPD combined powder plus potassium iodide
Total dissolved solids (TDS)	A measure of the dissolved material present in water. It is measured by filtering out the suspended solids, evaporating the filtrate and weighing the dissolved residue, or using a suitably calibrated conductivity meter. See *Conductivity*
Tri-halo-methanes (THM)	Chlorine that has reacted with organic compounds to form tri-halo-methanes. These substances can be absorbed through the skin, ingested and inhaled and cause symptoms of faintness, drowsiness, pseudo-asthma, and pseudo-influenza. The major THM produced is chloroform, ($CHCl_3$), which is an anaesthetic
Turbidity	A measure of the degree of fine suspended material in a sample, which reduces water clarity. Measured using a turbidimeter. Ideally turbidity in a pool should be less than 1.0 NTU post-filter and less than 2.0 NTU pre-filter
Turnover time	The time taken for the equivalent of the pool volume to pass through the treatment system
Urea	A component of sweat and urine which contains nitrogen
UV absorbance	The loss of light, usually at a specified wavelength, as it passes through water

1.3 Water treatment

1.3.1 General

Water treatment can be separated into two distinct categories, mechanical and chemical. Mechanical deals with filtration and circulation, while chemical deals with microbiological and organic contaminants and the mineral balance of water.

See Appendix A for the health considerations applicable to pool water pollution.

1.3.2 Mechanical

A swimming pool or spa can become contaminated by dirt carried on bodies and feet, hair, and lint from swimsuits. Wind-blown debris and material from the pool surround can also enter the pool. The accumulation of contaminants can create a hazard and also lead to the production of free floating or wall clinging algal blooms which could require unnecessary emptying and cleaning.

Good filtration and circulation are essential to ensure that water is distributed evenly throughout the pool or spa, ensuring proper mixing and eliminating any dead spots or debris. Another function is to remove suspended particles from the water. See Appendix B for information on coagulation and flocculation.

The pump keeps the pool or spa water constantly in motion. Water is pumped through pipes to support equipment where it is filtered, chemically treated and possibly heated, before it is returned to the pool or spa. Various valves, gauges, and meters are used to control and monitor this system.

1.3.3 Chemical

A swimming pool or spa becomes contaminated by oral and nasal discharges, skin shedding, sweat, urine, and occasionally faecal matter. A number of pathogenic and other microorganisms will accumulate, especially on the water surface where mucus has a tendency to gather. The most common health issues are eye, ear, nose, and throat ailments; infections of skin lesions; and enteric and urinary tract infections. Where water is treated and water quality maintained properly there is a low risk of cross-infection.

Chemicals are added to water to maintain safe water free of microorganisms (disinfection), aesthetically pleasing water (oxidation), and to control algal blooms (disinfection/algae prevention). Chemicals are also added to pool and spa water to control the overall mineral balance. This ensures swimmers' comfort, disinfectant efficacy, and the longevity of pool equipment and related surfaces, preventing unnecessary maintenance costs.

Dosing with chlorine is widely used as a disinfectant. Because free available chlorine (FAC) is destroyed rapidly by sunlight and by contaminants introduced by pool users (such as oils, cosmetics, dyes, and fibres from clothes), to ensure the presence of free available chlorine at all times all public pools shall have installed and use automatic dosing equipment.

See Appendix C for information on the chemical principles for chlorinated pools.

See Appendix D for alternatives to chlorine for pool disinfection.

See Appendix E for information on chemical dosing procedures.

See Appendix F for recommendations on the safe handling, storage, and management of chemicals.

See Appendix G for a checklist of duties and procedures for the safe operation of swimming pools.

1.3.3.1 Importance of pH control

Low pH values (below pH 7.2) in pool water enhance corrosion of fittings and equipment, and irritate body tissues. High pH values (greater than pH 8.0) are corrosive on some metals such as brass and aluminium, also irritate body tissues, and may promote formation of calcium carbonate scale. Regardless of the disinfection mode chosen, it is recommended that pool water pH values be maintained between 7.2 and 8.0 at all times. This is particularly important for chlorine because pH controls its efficacy.

1.3.3.2 Chemical water balance

Chemically balanced water is water in which calcium carbonate does not dissolve or precipitate. Balanced water should neither form scale on pool structures nor dissolve concrete or corrode pipework, and should therefore prolong the life of the pool and fittings. See Appendix H9 for more information.

1.3.4 Discharge from pools

Pool discharges, leakages, spillage, and washing shall comply with the current legislation, and local authority bylaws.

NOTE — Requirements vary between authorities, so all territorial authorities and regional councils should be consulted.

1.3.5 Training

1.3.5.1

The operation of each public pool water treatment system shall be the responsibility of a person or persons meeting relevant NZQA Unit Standards as required by the owner of the pool.

1.3.5.2

When the pool is operating, the management of pool water quality shall be under continuous technical supervision and the suitably qualified person(s) shall be readily accessible. See 2.3.

1.3.5.3

Some of the chemicals used for water treatment are hazardous and are subject to controls imposed by the Hazardous Substances and New Organisms Act (HSNO Act). It is important that all persons handling chemicals take appropriate safety precautions including wearing safety clothing, goggles, and a respirator if necessary. For certain chemicals, such as chlorine, the person handling the substance may need to be an approved handler and hold a certificate to confirm they have the necessary qualifications.

1.3.5.4

A person or persons who advise on water quality issues in pools shall be a suitably qualified person, preferably meeting relevant NZQA Unit Standards.

1.4 Water quality criteria and testing frequencies

1.4.1 Introduction

To ensure that a pool is not a health risk and provides for user comfort it shall meet the criteria outlined in this section (see table 1).

Sampling and testing shall be undertaken at frequencies outlined in tables 2 and 3 to provide an effective way of determining whether the required minimum standards are consistently achieved. Monitoring microbiological quality of the water to the standards outlined in 1.4.4 and table 4 shall also be undertaken.

Maintenance of accurate and complete records is essential to ensure good pool management procedures and full sampling and testing records shall be kept. See Appendix H1 for more information.

1.4.2 Sampling and record-keeping

Sampling technique is important and sampling shall always be carried out using recognised standard procedures, and by a suitably qualified person. Particular care shall be taken to avoid contamination of the sample. Samples should be taken at a depth of approximately 300 mm below the surface.

The following information shall always be recorded to assist interpretation of the sampling results:

(a) Location of the sampling point; and

(b) The date and time the sample is taken.

For further information on microbiological sampling, see Appendix H.

1.4.3 Chemical criteria and frequency of testing

The sample is to be representative of the water the pool users can expect to encounter. The most appropriate place to sample from is midway between the water entering the pool from the treatment system and exiting the pool. This sample point shall be used for all chemical sample compliance testing.

Other samples taken for quality control purposes shall be taken from the relevant sampling points.

Table 1 provides water quality criteria for swimming pools and spa pools. The table includes lowest, highest, and the most desirable values.

Table 2 and table 3 prescribe the minimum chemical testing frequencies for swimming pools and spa pools.

See Appendix H for information on water quality test procedures, test kits and equipment for pool water testing.

Appendix J provides a troubleshooting table to assist in the identification and resolution of various problems likely to be encountered in pool management.

Table 1 – Chemical water quality criteria – Swimming pools and spa pools

Characteristic or chemical	Lowest value	Highest value	Most desirable value	Comments
pH	7.2	8.0	7.4 – 7.6	Too low: plaster and concrete etching, eye discomfort, corrosion of metals, and vinyl liner damage, could occur Too high: Low chlorine efficacy, scale formation, cloudy water, and eye discomfort could occur
Alkalinity (as $CaCO_3$):				For both (a) and (b):
(a) Gas chlorinated pools and pools using trichloroisocyanuric acid	100 mg/L	200 mg/L	120 – 150 mg/L	Too low: – pH bounce, corrosion tendency
(b) Pools with other forms of chlorination	50 mg/L	200 mg/L	60 – 120 mg/L	Too high: – Cloudy water, increased scaling potential, pH tends to be too high
Calcium hardness	40 mg/L	300 mg/L	See saturation index (SI)	Too low: – Etching and corrosion Too high: – Scaling and cloudy water
Free available chlorine (FAC):				For both swimming pools and spa pools, a heavy pool bathing load may require operation at or near maximum levels See the risk management plan for FAC management Chlorine + Other means Chlorine plus Ozone, UV, or ClO_2
(a) Swimming pool:				
Chlorine alone	1.5 mg/L	7.0 mg/L (1)	2.5 – 5.0 mg/L	
Chlorine + Other	0.5 mg/L	5.0 mg/L	1.0 – 2.5 mg/L	
(b) Spa pools and hot tubs:				
Chlorine alone	2.0 mg/L	7.0 mg/L(1)	3.0 – 5.0 mg/L	
Chlorine + Other	1.5 mg/L	7.0 mg/L(1)	3.0 – 5.0 mg/L	
Combined available chlorine (CAC)	Not detectable	1.5 mg/L	< 0.5 mg/L	High combined chlorine residuals can result in a sharp chlorinous odour and cause eye irritation
Total bromine:				For both swimming pools and spa pools: If using a chlorine test kit multiply the reading by 2.2 for total bromine
(a) Swimming pools	4.0 mg/L	10.0 mg/L	4.0 – 6.0 mg/L	
(b) Spa pools and hot tubs	4.0 mg/L	10.0 mg/L	5.0 – 7.0 mg/L	

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Table 1 – Chemical water quality criteria – Swimming pools and spa pools (continued)

Cyanuric acid	25 mg/L	100 mg/L	30 – 60 mg/L	Too low: – Chlorine residual rapidly destroyed by sunlight Too high: – Reduces the chlorine's efficacy
Total dissolved solids (TDS)		Less than 2000 mg/L above make-up water just for spa pools	Less than 1000 mg/L above make-up water just for swimming pools	TDS identifies a build up of impurities which should be controlled by partial drain/refill with fresh water, typically at a rate of 30 L/person/ day. These TDS limits do not apply to salt chlorinated pools. Follow the manufacturer's recommendations

NOTE –

(1) High chlorine residuals could potentially increase THM production.

(2) If a pool is operated with a pH above 8.0, it must be suitably justified via a risk management plan approved by the pool owner and be under the control of a suitably qualified person.

(3) This table does not apply when a pool is being superchlorinated or an equivalent acceptable chemical cleaning method is used.

(4) There is no test specified at this time for water clarity. Water clarity should be maintained so that lane markings or other features on the pool bottom at its greatest depth are clearly visible when viewed from the side of the pool. Turbidity is a measure of water clarity and can be used as a useful diagnostic tool.

(5) For additional information on spa pools and hot tubs see 1.5.

(6) The highest value for water temperature shall be 40°C and the lowest and most desirable values will depend on personal preference of the users, or the pool manager.

Table 2 – Minimum frequency of chemical testing for swimming pools

Test(1)	Public pools	Domestic pools
pH(2)	Prior to daily use then every 3 hours	Twice per week
Alkalinity	Weekly	Monthly
Calcium hardness	Monthly	Monthly
Free available chlorine (FAC) (bromine)(2)	Prior to daily use then every 3 hours	Prior to use
Total chlorine (bromine)(3)	Daily	NA
Cyanuric acid (with or without chlorinated cyanurates)	At beginning of season, then fortnightly	At beginning of season, then monthly
Chloride if saline pool water is electrolysed	At beginning of season, then weekly	At beginning of season, then monthly
Total dissolved solids (TDS)	At beginning of season, then weekly	Yearly

NOTE –

(1) More frequent testing will be necessary for effective water quality control in pools with an instantaneous bathing load greater than they are designed for.

(2) If continuous automatic chemical residual controllers are used, then reduction of the frequency of sampling to no fewer than two samples per day is appropriate. Oxidation reduction potential (ORP) measurement does not meet this requirement.

(3) Combined available chlorine (CAC) is calculated by subtracting measured free available chlorine (FAC) from measured total chlorine.

Table 3 – Minimum frequency of chemical testing for spa pools

Test	Public pools	Domestic pools
pH	Prior to daily use, then every two hours	After filling, then twice weekly
Alkalinity	After filling, then weekly	After filling, then monthly
Calcium hardness	After filling, then weekly	After filling, then monthly
Free available chlorine (FAC)	Prior to daily use, then every two hours	After filling, then twice daily
Total chlorine (Bromine)	Daily	Weekly
Total dissolved solids (TDS)	Daily	Monthly

NOTE –

(1) Where the spa is under continuous heavy loading, increase the frequency of tests.

(2) Combined available chlorine (CAC) is calculated by subtracting measured free available chlorine (FAC) from measured total chlorine.

1.4.4 Microbiological criteria for public pools

1.4.4.1 Microbiological water quality criteria

Methods used for determining levels given in table 4 will vary according to laboratory facilities available. As a general rule those methods described in the APHA publication *Standard methods for the examination of water and wastewater* or AS/NZS 4276 are recommended.

1.4.4.1.1

Compliance with criteria set out in table 4 is mandatory for all types of pools, with the exception of standard plate count (SPC) (incubated at 37°C) which may not be applicable to a geothermal or open air pool depending on the environmental setting. The standard plate count is not a good indicator of the actual health risks, as no differentiation is made between pathogenic and normally non-pathogenic organisms. As an estimation of viable organisms enumerated by the method used, compliance does show the relative effectiveness of disinfection.

1.4.4.1.2

Non-compliance with these criteria in any one sample should not be considered in isolation, as it will be related to non-conforming values for pH and the particular sanitiser used, and identifies the necessity for corrective action and additional sampling. While it is not practical at this time to be able to set water quality criteria for protozoa (such as *Giardia* or *Cryptosporidium*) because of the difficulty with detection and monitoring, the public health risk posed by these organisms entering a swimming pool can be greatly reduced by following the procedures detailed in Appendix A.

Table 4 – Microbiological water quality criteria

Test	Level	Main source
Standard plate count (SPC)	Less than 200 per mL	General bather hygiene
Faecal coliforms or *Escherichia coli (E. coli)*	Less than 1 per 100 mL	Faecal contamination Excess bathing load
Staphylococcus aureus	Less than 100 per 100 mL	Skin Excess bathing load
Pseudomonas aeruginosa	Less than 10 per 100 mL	Regeneration in pool Excess bathing load

1.4.5 Minimum frequency of microbiological monitoring

The following microbiological monitoring programme shall be used for public pools:

(a) Initial (such as, at the beginning of the season);

(b) Monthly;

(c) If the pool does not comply with disinfection parameters over a period of 12 hours.

NOTE — More frequent monitoring is recommended if a problem is detected. The specified monitoring frequencies are the absolute minimum necessary for monitoring pool water quality unless a lower frequency is justified in a risk management plan for the pool. A pool which is abnormally crowded, has incomplete chemical and physical water quality records, or which has recently shown unsatisfactory results, requires more frequent microbiological checks than pools with average pool loading and satisfactory monitoring records.

1.4.6 Sources of contamination

If the water used to fill the pool, including make-up water, is not of a good quality, the water should be treated before it enters the pool.

Human faeces can carry a range of pathogenic organisms. Unfortunately, occasional accidents do happen in swimming pools and, apart from the aesthetic offence, water can quickly disperse pathogens and put other users at risk.

Immediate action shall be taken following a 'faecal accident'. Details of the incident and remedial action shall be documented. Procedures to be followed are provided in Appendix A.

1.5 Additional requirements for spa pools and hot tubs

1.5.1 General

Temperature is controlled up to 40°C. Spas and hot tubs usually have multiple water venturi jets. All spas and hot tubs shall have dual suctions or approved grates to stop body, hair, and clothing entrapment. Surface skimmers are recommended to assist in the removal of body fats and surface debris.

1.5.2 Pool load factor and need for treatment

Excessive pool load factors are often reached because of the volume of water in spas relative to their seating capacity.

The pool load factor is affected by the:

(a) Close proximity of people in a spa pool, so that pathogens have a very short period in which to be sanitised, and are more easily transferred;

(b) Temperature of spas which enhances the growth of some pathogens;

(c) Transportation of pathogens throughout the pool, and via aerosols because of rapid water movement;

(d) Filtration effectiveness;

(e) Greater release of body fats into the pool because of higher water temperatures.

NOTE — To cope with high pool load factors, and rapid build-up of waste compounds the FAC ideal range has to be higher than that of swimming pools. See table 1.

1.5.3 Change of water

Whether in use or not, spa water should be changed either weekly in public spas and monthly for domestic spas, or more frequently if the water is not clear, has an unpleasant smell, or exceeds the TDS limit.

Changing the water is the only sure way to remove the solids and other wastes. Waste compounds like TDS will increase rapidly, accumulating compounds like chlorides, calcium, magnesium, sulphates, and carbonates through normal use. Excessive TDS and other wastes will reduce water clarity, and reduce disinfectant efficacy.

Spa pool water should also be changed when superchlorination or an equivalent acceptable method is unable to cope with any of the following:

(a) Loss of clarity or change in water colour;

(b) Presence of unpleasant odours;

(c) Inability to maintain chlorine residual;

(d) CAC exceeds 1.5 mg/L.

1.6 Specific requirements for geothermal pools

1.6.1 General

Geothermal pools shall not exceed a maximum temperature of 40°C.

Geothermal water may contain hydrogen sulphide (H_2S). H_2S is heavier than air, and can accumulate to lethal concentrations on the surface of the pool if not adequately ventilated.

Geothermal waters require some special precautions because of the possibility of contracting primary amoebic meningoencephalitis (PAM). The pathogenic protozoa that cause this disease live in the soil, and there is a potential hazard wherever warm waters that have been in contact with soil or soil particles are used for pools. Amoebae cannot survive in hot (above 90°C) water, but although hot geothermal waters at source may be free of amoebae, contamination can occur after cooling by flowing through earth drains, mixing with warm groundwaters (such as through leaking well casings) and transfer of soil into pools.

1.6.2 Special requirements for unfiltered, non-recirculating geothermal systems

If a geothermal pool is not operated as a recirculated system, that is, it is a 'fill and draw' system, additional means such as those outlined in this section shall be used to maintain the water in a sanitary condition.

There is a strong possibility of pathogenic amoebae being present in untreated geothermal waters. Users of such pools shall avoid immersion of their head to ensure PAM does not enter their body.

The following conditions shall apply to such pools:

(a) The pool shall be operated on a flow-through principle with a flow rate of at least one quarter of the pool volume per hour;

(b) The pool shall be emptied completely at least daily and the sides and bottom brushed with a chlorine solution (for example, 50 g of calcium hypochlorite per 10 L of water) and then washed down with clean water;

(c) Diving, sliding, or other activities in which people are likely to immerse their heads under the water shall not be permitted;

(d) Slides, diving boards, and other structures which encourage diving, jumping, or similar activities involving risk of head immersion shall not be installed;

(e) Notices shall be erected warning against immersion of heads in the pool. These notices shall be prominently displayed using the words 'Health Warning – Do Not Immerse Head'. Consideration shall be given to the use of sketches and multilingual presentation to enhance this message.

Geothermal water sources shall be adequately protected from surface water run-off and soil contamination. Bores should be lined and the casing sealed into the strata.

Waters containing more than 1% of sodium chloride, or with a pH value above 8.5 and a high mineral content are less likely to contain pathogenic amoebae than other geothermal waters.

1.6.3 General precautions

The following are general precautions which shall be taken for all geothermal pools as pathogenic amoebae may be present in soils:

(a) Pave all pool surrounds to provide a sanitary barrier between the pool and any soil or grassed areas;

(b) Provide a physical barrier between any soil or grassed areas and the pool surrounds sufficient to exclude spectator access, thus minimising the risk of soil contamination likely to introduce soil amoebae;

(c) Provide a disinfected flow-through foot bath sited where it is impossible to enter the pool without using it. This shall be drained to waste.

PART 2 POOL RISK MANAGEMENT PLAN GUIDES

2.1 Introduction

Pool owners have a public health responsibility to ensure that the pool is a safe environment. Water safety is brought about by the care and consideration people have for activities and actions in the vicinity of the pool as well as the water treatment processes used in the pool.

By its very nature the water in a swimming pool is continuously at risk of being, or becoming, unsafe. A well thought out pool risk management plan (PRMP), designed specifically for the pool, will provide pool users with confidence that the water is consistently safe.

Part 2 provides an overview of the processes involved in preparing, implementing, reviewing, and updating a PRMP. This comprises a series of guides, each specific to an aspect of pool water quality risk.

This risk assessment process is based on the premise that there are many events capable of impacting on pool water quality, meaning the pool water may not meet the requirements of Part 1. For each event identified, indicators which will alert the pool manager to an occurrence are listed and remedial measures suggested.

It is generally impossible to reduce the level of any risk to the point where it is non-existent, but most risks can be reduced to as low as reasonably practicable by applying appropriate management controls.

A PRMP provides direction for improvements and expenditure, is a safeguard against changing operations, staff, and management, and is a learning resource for new staff.

Fundamental risk management information is provided in Appendix K.

2.1.1 Contents of a pool risk management plan

A PRMP is a systematic assessment of every aspect of providing safe and aesthetically acceptable pool water, to identify the events that could cause water quality to deteriorate and become unsafe, then provide appropriate management practices to reduce the likelihood of adverse events occurring and mitigating their effects should they occur.

2.1.1.1

The PRMP covers two aspects of the pool water quality: treatment and contamination event management.

2.1.1.2

The PRMP helps identify whether any of the following four barriers to contamination are missing:

(a) Minimising contaminants in the pool water;

(b) Removing particles from the water (where many of the microorganisms hide);

(c) Killing microorganisms;

(d) Minimising recontamination within the pool.

2.1.1.3

The PRMP addresses the following questions:

(a) What could happen to cause the water quality to deteriorate and become unsafe?

(b) Which of these factors need urgent attention?

(c) How to know when the water quality is deteriorating to a point where action is needed?

(d) How to respond if action is needed?

(e) How to stop this happening in the future?

2.1.2 Preparing a risk management plan for a swimming pool

Various risk management guides are provided in 2.2 to 2.13, to facilitate the preparation of a PRMP. In many cases the guides may be used without change. In other cases, they may be tailored to suit the particular need by both adding and deleting material (see Appendix K for information on estimating risk).

2.1.3 Risk levels

There are four levels of risks associated with pool water quality:

(a) Microbiologically or chemically (indirectly, such as low FAC) unacceptable water quality, that could lead to a public health risk resulting in the infection of bathers and consequences such as gastro-intestinal upset or skin infections;

(b) Chemically unacceptable water of poor aesthetic quality (such as CAC too high, or poor clarity) resulting in a poor swimming experience for pool users and loss of patronage, loss of income, poor image, and so on;

(c) Chemically unbalanced water that, over the long term, may result in corrosion of or scale formation on pool treatment materials;

(d) Increased drowning risk due to lack of water clarity. Drownings have been attributed to lack of visibility to see bathers in and under the water.

2.1.4 Enabling the plan

The PRMP will guide both day-to-day actions and long-term planning. The plan will:

(a) Identify regular monitoring and inspections that signal deteriorating pool water quality and prompt action;

(b) Identify regular ongoing maintenance to reduce the chance of failure of any of the barriers to contamination;

(c) List where to get help, who needs to know what about the status of the pool water quality, and how quickly they need to know;

(d) Provide direction for improvements and expenditure.

2.1.5 Plan improvement review

A PRMP is a dynamic document and its continued relevance should be reviewed annually, after any significant change to the pool, and as a result of finding a weakness in the plan.

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Each guide includes a section which may be used as the basis for such a review. The 'improvement schedule' should make clear which actions can be achieved with existing resources and which will require additional resources.

2.1.6 Risk information table

For each guide topic the associated events and their causes are summarised in a table which adds information about the risk, preventive measures, and corrective action. The general monitoring guide (2.2), and the staff training guide (2.3) impact on every other guide in Part 2, and should be consulted in each case. While not every detail is given for how their information is linked with the specific guide, the links are many and are important.

2.1.7 Contingency plans

Each risk management guide contains a contingency plan which requires a responsibility hierarchy.

All staff responsible for pool water quality are to be actively involved with these contingency plans. If any pool water quality issues arise, day-to-day responsibility is that of the duty pool manager. If these events require external action, the designated representative of the pool owner (as appropriate) shall take responsibility. If a health issue arises, the public health unit is to be contacted.

2.1.8 Power failure

In the event of power failure, in all cases pool water quality will be compromised as recirculating pumps will have stopped running and therefore pool water will no longer be treated. The pool shall be closed.

2.1.9 Pool closure

If there is an identified public health risk that results in the pool closure, as per the PRMP, the pool shall remain closed until the risk has been remedied.

2.2 Risk management guide – General monitoring

2.2.1 Introduction

This guide deals with the collection of samples of pool water, and their analysis. See Part 1 for guidance on which elements are to be monitored for and how often. Part 1 also contains advice on sample analysis.

2.2.1.1

Monitoring samples are collected to gather information to assist with:

(a) Management of the pool water quality;

(b) Treatment process control;

(c) Checking whether the pool water meets the requirements of Part 1 of this Standard.

2.2.1.2

Unreliable water quality information can lead to poor pool water quality, poor pool management decisions, and may result from one or more of several factors:

(a) Poor sampling procedures;

(b) Inadequate test equipment or reagents;

(c) Unsuitable test methods;

(d) Poor record-keeping;

(e) Inadequate staff training or failure of staff to follow documented procedures.

If the monitoring is not done properly, incorrect water quality information may be used to make decisions about the operation of the pool. This may lead to bather complaints and possible sickness.

2.2.2 Risk summary

The event creating the greatest risk in monitoring is the reporting of incorrect water quality data that are used for supply management decisions.

The most important preventive measures are to:

(a) Collect, handle and where relevant, transport samples correctly (see 1.4.2 and Appendix H);

b) Use suitable, approved methods of analysis, and quality assurance systems;

(c) Make sure all instrumentation and methods used are calibrated;

(d) Make sure that the staff who collect samples, or analyse them, are properly trained.

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2.2.3 Risk information table

Without reliable information about water quality there is a high risk that essential and proper management of the water quality in an aquatic facility will be compromised. Good management and operational decisions to protect public health depend on reliable information. Knowledgeable and skilled staff are also essential to minimise the risks associated with pool water monitoring.

2.2.3.1 Event – Incorrect water quality data used for pool

Reliable information about water quality is essential for the proper management of a pool. The causes and corrective actions for these are shown in table 5.

Table 5 – Risk information – Incorrect data used for pool management

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Inappropriate/ incorrect sampling/non-representative sampling frequency	Prepare a sampling plan (See Part 1 for frequencies required) Ensure purpose of taking the sample is established Determine that the following are correct: – sampling location – sampling frequency – sampling procedure See Part 1 for monitoring requirements Ensure that the sampling container is correct and correctly preserved (if appropriate) Ensure that sample transport procedures are satisfactory (as appropriate) Ensure staff carrying out sampling are properly trained	Checks made of sampling plan, sampling procedures, and sampling frequency	Poor records/data entry checks not signed off Unacceptable number of errors detected during checks Process control failures Checks of sampling procedures not undertaken Unexplained test failures	Improve sampling plan/procedures Find the reason for taking the sample (compliance, process control, and so on) Undertake review Consult Part 1 Check with laboratory Identify staff training needs and provide training
Inadequate/ incorrect test equipment or incorrectly calibrated test equipment	Use equipment that meets the requirements of Part 1 Carry out routine maintenance as specified by the manufacturer Undertake calibration procedures as specified by the manufacturer, or have them carried out independently	Check equipment calibration and maintenance records Compare samples/ results with a suitable analytical laboratory	Results not reproducible or 'strange' No, or incomplete, record of calibration and maintenance	Consult manufacturer for guidance on equipment specifications Put maintenance schedule in place See Part 1 or a suitable analytical laboratory for guidance on calibration

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Table 5 – Risk information – Incorrect data used for pool management (continued)

Inadequate reagents	Ensure shelf-lives of reagents are known and date at which they are to be used again noted on the container Ensure reagents are stored appropriately (usually this is in the dark, and cool) Maintain records for the preparation of reagent solutions and calibration standards. Preparation calculations should be independently cross-checked Cross check reagent quality by repeat analysis of a sample using old and newly-prepared reagents when new reagents are to be used	Compare samples/ results with a suitable analytical laboratory Reagent preparation records	Results not reproducible or 'strange' Reagent preparation records identify reagents are too old	Consult Part 1 or suitable analytical laboratory for reagent stability information Provide and use appropriate storage Start keeping reagent preparation records
Inappropriate method or incorrect calibration	Refer to manufacturer or suitable analytical laboratory to find out which methods can be used Ensure that the calibration procedures specified in the method are followed Ensure staff are adequately trained in calibration procedures required in the method	Compare samples/ results with a suitable analytical laboratory	Results not reproducible or 'strange'	Consult Part 1 or with a suitable analytical laboratory for reagent stability information Improve documentation of method Identify staff training needs and provide training
Inadequate or incorrect monitoring records	Undertake regular checks of records Ensure staff are trained in the maintenance of records Ensure that independent checks are made on data entry	Check the monitoring and training records	Poorly kept monitoring records (for example, sampling location, date, illegible writing	Start checks/audits Identify staff training needs and provide training Start independent checks

Table 5 – Risk information – Incorrect data used for pool management (continued)

Failure of staff to follow the analytical method and other related quality assurance procedures	Ensure staff are trained in the analytical method being used and in associated quality assurance procedures Periodically split a sample and have it analysed by two staff members Periodically split a sample and have it analysed by an independent analyst or laboratory	Compare samples/ results with a suitable analytical laboratory Check training records	Poor agreement in samples/results compared with a suitable analytical laboratory Variable results in sample analysed by two staff members	Identify staff training needs and provide training Undertake split sample analysis

2.2.4 Contingency plan

If an event does occur despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.2.4.1 Event – Poor quality assurance, or quality control for monitoring, or both

The indicators provided in table 6 will help determine poor quality assurance, or quality control for monitoring, or both. A list of required actions to address this contingency is also provided.

Table 6 – Event indicators and contingency actions – Quality of monitoring

Indicators	Too many errors detected during audits or surveillance Too many process control failures Too many outliers shown by inter-lab quality control studies Repeated unexplained compliance test failures (FAC/TAC)
Required actions	Full audit of quality procedures Identify and resolve deficiencies in equipment/methods/staff training Identify all analysis records that may have been adversely affected Inform the facility manager if compliance with Part 1 may have been affected Once the cause of the poor performance has been identified, correct it Record the reason for the failure and the steps taken to rectify Modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.2.5 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 7 provides the detailed information for checking pool data monitoring.

Table 7 – Pool data monitoring data

What to measure or observe	Record audits Maintenance and calibration logs Laboratory test data Internal quality control checks
How often	Records should be audited every 6 months Laboratory test data should be reviewed monthly Quality control checks should be undertaken monthly
What to do with the results	Record results to meet requirements of this Standard or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with the quality of pool water are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to pool water quality Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results, or indicate that poor water quality is reaching customers, then review the procedures for managing monitoring activities Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification, for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to monitoring protocols are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.3 Risk management guide – Staff training

2.3.1 Introduction

The ability of staff to make correct decisions is fundamental to the production and maintenance of good pool water quality. This guide addresses inadequate training which causes the pool water quality to not meet requirements of Part 1.

2.3.2 Knowledge and skills

It is critical that staff have adequate knowledge about acceptable pool water quality, and the ability to apply this knowledge correctly so that the risk to the public is minimised.

The knowledge and skills required to manage and operate a pool water treatment process include, but are not limited, to the following:

(a) Management;

(b) Financial management and planning;

(c) Asset management;

(d) Risk management;

(e) Public health issues;

(f) Customer relations and charters;

(g) Technical design;

(h) Detailed technical knowledge;

(i) Proven ability to apply technical knowledge that is, operating skills in treatment operations;

(j) Use of an appropriate data recording system (for example, test results);

(k) Legislation and legal responsibilities;

(l) Monitoring responsibilities and skills;

(m) Laboratory skills;

(n) Operating skills.

2.3.3 Risk summary

The event creating the greatest risk associated with staff training is the lack of, or incorrect, training.

The most important preventive measures are:

(a) Correct and appropriate NZQA-based training – theory and practical;

(b) Onsite training and experience – from equipment suppliers;

(c) Onsite training from experience – shared appropriate knowledge.

2.3.4 Risk information table

Reliable operation of the water treatment is essential for the proper management of pool water quality. Knowledgeable and skilled staff have an essential role in minimising the risks associated with running pools particularly when monitoring data and interpreting the results. Inadequate training will lead to a high risk that water quality does not meet the requirements of Part 1 and public health is compromised. The consequences of the event, and therefore the level of risk, will be influenced by the severity of the issue that arises from the lack of appropriate training and knowledge.

2.3.4.1 Event – Inadequate knowledge arising from inadequate training.

Events that can result from inadequate knowledge arising from inadequate training are shown in table 8.

Table 8 – Risk information – Inadequate knowledge

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Inadequate knowledge arising from inadequate training	Suitable training is planned for and completed New knowledge is shared among staff Operations manuals are regularly used and updated by all relevant staff Knowledge is actively sought from manufacturers and suppliers Relevant experience is shared among staff	Staff training records General/current knowledge of staff Accurate records of pool water quality Well-run operational equipment Maintenance records	No or incomplete staff training records Basic questions cannot be answered correctly No operations manuals, or operational manuals out of date	Maintain staff training records Staff to meet relevant NZQA unit standards

2.3.5 Consequences of inadequate training

Events that can result from inadequate training, and their consequences for public health are shown in table 9.

Table 9 – Inadequate training consequences

Events	Consequences
Introduction of microbiological contaminants into the pool water (cleaning floors into pool water), or the inadequate inactivation (insufficient disinfection), or removal, of microbiological contaminants (insufficient filtration)	Causing sickness from disease-causing organisms
Introduction of incorrect levels of treatment chemicals	Causing sickness from exposure to incorrect chemical levels Making pool use unpleasant

2.3.6 Causes

Inadequate training contributes to the events outlined in table 9.

2.3.7 Preventive measures

The following sets out the preventive training measures that need to be taken:

To determine whether the appropriate competencies exist within the organisation or structure, and whether upskilling or cross-skilling (such as training) is required, a detailed assessment of training needs is required.

For a pool/aquatic centre of a company or local authority this will be a formal process, but for owners of other smaller pools with limited numbers of staff or those only serving a few customers the process can be informal. Regardless of the approach adopted the conclusions and recommendations shall be documented.

2.3.7.1

The generalised procedure for such an analysis is as follows:

(a) Prepare job descriptions: Each employee needs a detailed job description. As a general guideline the preventive measures listed in table 8 can be used to define duties.

These general duties are normally further defined as job description duties in (b), by using words/phrases such as: ‘responsible for’ , ‘complete’, ‘carry out’, ‘provide’, ‘control’, and so on;

(b) Training needs analysis: This is sometimes known as ‘gap’ analysis, or ‘skill gap’ analysis. This has to be matched to organisational requirements.

From the job description, the following information is derived in a formal meeting with the job holder:

(i) Duties from the job description are defined using the risk management plans as a guideline, along with key result areas from these descriptions and performance criteria

    (ii) Identified training needs
    (iii) Ranking and prioritisation of training needs developed from a skill audit report or by taking into account recognition of current competency (RCC);

(c) Training programme development:

From the training needs analysis the most suitable type of training can be determined. Training needs can be met by a mix of:

    (i) On-the-job training followed by onsite assessment by recognised job assessors
    (ii) Suitable off-site NZQA-recognised training: cross-skilling and upskilling with possible onsite competency assessment
    (iii) Informal meetings and conferences
    (iv) Encouragement to belong to related professional and technical organisations
    (v) Internal advocacy of the 'knowledge industry' including internal distribution of technical journals and encouragement to attend local interest meetings
    (vi) Recognition of current competencies.

2.3.8 Development and budgeting of a training programme for pool/aquatic centre staff

For small systems the approach adopted can be informal, but in essence the same elements need to be evaluated regardless of the size of the pool and its water treatment system. It is recognised that the ensuing documentation will vary in complexity, and the approach adopted to develop this documentation may differ.

In summary the three key steps needed to meet the requirements of this risk management plan are:

(a) Training needs analysis as described in 2.3.7 (b);
(b) Documented individual staff member training plans;
(c) Auditing of the training programme to assess whether the programme has been initiated and there is proof that the required levels of competency have been achieved.

Pool water treatment processes are managed and operated by people with a range of skills from 'hands-off' managerial input to 'hands-on' operation. The training programme for this range of skill bases can be developed from the range of available training programmes.

2.3.9 Links with other components of the pool system

Competency is an integral component of all the risk management plans. The specific training requirements for the risk management plans will depend on the staff level involved, existing core skills, and the assessed knowledge/skill gaps that exist.

2.4 Risk management guide – Media filtration without flocculation

2.4.1 Introduction

Media filtration is used to remove suspended particles down to about 20 microns in diameter. While this filtration will not remove microorganisms such as *Giardia* and *Cryptosporidium*, it will capture dirt and particulate material introduced during general use of the pool. By reducing contaminants, the disinfection systems can work more effectively.

As this filtration mode will not remove most microorganisms, other forms of additional protection are frequently used; for example, chlorination – primary disinfection, secondary disinfection (such as UV irradiation, ozone, chlorine dioxide); filtration able to remove smaller particles (pre-coat filtration or flocculation with media filtration); pool use/bather control through education, and showers for pre-pool use.

2.4.1.1

If an event occurs during the media filtration process (that is, the process doesn't work properly), any of the following could result:

(a) If particulate pollution is not removed, there could be high chlorine demand, compromised disinfection, and microorganism survival;

(b) If particles are not removed, water becomes cloudy, pool use becomes unpleasant;

(c) If pollution is not removed, disinfection by-products such as chloramines are formed making pool use uncomfortable.

2.4.1.2

Several factors influence the efficacy of the media filtration process:

(a) Pool water use;

(b) Water quality;

(c) High use or high dirt load, which can rapidly clog the filters, and require more frequent backwashing before the particulate pollution makes its way through the filter; and

(d) Adequate filter backwashing.

2.4.2 Risk information table

Reliable information about water quality is essential for the proper management of a pool. Knowledgeable and skilled staff are also essential to minimise the risks associated with poor pool water quality. The general monitoring and staff training guides in 2.2 and 2.3 should be implemented.

2.4.2.1 Event – Particulate pollution not removed

Failure to remove particulates creates a high level of risk and is likely to result in hazards, such as microorganisms present (for example, *Giardia* and *Cryptosporidium*), poor pool water quality, compromised bather comfort, increased chlorine demand, and greater potential for the creation of chloramines. The consequences of the event, and therefore the level of risk, will be influenced by the quality of the pool water and the effectiveness of treatment processes, filtration, and disinfection. Event consequences are shown in table 10.

Table 10 – Risk information – Particulate pollution not removed without flocculation

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Maintenance inadequate	Routine maintenance schedule for the filter and its media Knowledge of media condition Adequate records of filter operation including backwashing	Maintenance log Filter performance (pre versus post-filter water quality), adequate dirt removal (for example, turbidity less than 1.0 NTU after filtration, and less than 2.0 NTU before filter)	Maintenance log not signed off Pool filter water quality unacceptable	Identify cause of fault and rectify Inspect media quality Start monitoring programme
Operation incorrect	Routine operational schedule for the filter and its media Suitable training/ experience of media filter operation Adequate records of filter operation	Maintenance log Proof of suitable training	Maintenance log not signed off No suitable training evidence	Ensure adequately detailed operations manual is being used Seek suitable training

2.4.3 Contingency plans

If an event does occur despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.4.3.1

The event indicators in table 11 may be a sign of an increased likelihood of *Giardia* and *Cryptosporidium* being present. A list of required actions to cope with this contingency is provided.

Table 11 – Event indicators and contingency actions

Indicators	Post filter/pool water clarity (high turbidity of filtered water) Advice from public health units of elevated occurrences of giardiasis or cryptosporidiosis reported in the community
Required actions	Immediately close the pool to the public until water of acceptable quality can again be supplied Identify the cause of inadequate filtration and rectify Restart plant operation Record the cause of the failure and the corrective steps taken Review the pool PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.4.4 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated.

Table 12 provides detailed information for checking filtration events.

Table 12 – Media filtration without flocculation assessment

What to measure or observe	Pre and post filter water quality
How often	As required
What to do with the results	Remedy with reference to 1.4 Record results to meet requirements of this Standard or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to public health arising from this pool water quality element Should this review show any unusual incidents, identify where proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality has occurred, then review the procedures for managing the filter Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to the filter are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.4.5 Risk summary

The event creating the greatest risk in media filtration without flocculation is poor removal of particles/particulate pollution.

The most important preventive measure is to ensure media filter maintenance and operation can be controlled to match the changing pool water quality.

2.5 Risk management guide – Media filtration with flocculation

2.5.1 Introduction

Media filtration with chemical enhancement (flocculation) is used to remove suspended particles down to about 5 microns in diameter. This filtration will remove microorganisms like *Giardia* and potentially *Cryptosporidium*, and will capture dirt and particulate material introduced during general use of the pool. By reducing contaminants, the disinfection systems can work more effectively.

As this filtration mode will not remove all microorganisms, other forms of additional protection are frequently used; for example, primary disinfection (chlorination); secondary disinfection (for example, UV irradiation, ozone, chlorine dioxide); filtration able to remove smaller particles (pre-coat filtration or flocculation with media filtration); pool use/bather control through education, showers for pre-pool use.

2.5.1.1

If an event occurs during the media filtration with flocculation process (that is, the process doesn't work properly), any of the following could result:

(a) If particulate pollution is not removed, there could be high chlorine demand, disinfection is compromised, and microorganisms survive;

(b) If particles are not removed, water becomes cloudy, pool use becomes unpleasant;

(c) If pollution is not removed, disinfection by-products such as chloramines are formed making pool use uncomfortable;

(d) Chemical floc is not caught in the filter, forming cloudy chemical floc in the pool water;

(e) Alkalinity and pH will be reduced by chemical floc formation; flocs will dissolve if the pH is too low or too high.

For the whole process to work as well as possible, take care in the operation of chemical dosing and control systems.

2.5.1.2

Several factors influence the efficacy of the media filtration with flocculation process:

(a) Pool water use;

(b) Water quality;

(c) High use or high dirt load, which can rapidly clog the filters and require more frequent back-washing before the particulate pollution makes its way through the filter; and

(d) Chemical dosing is controlled to ensure all chemical flocculant that is added is caught in the media filter, and not permitted to pass through.

2.5.2 Risk information table

Reliable information about water quality is essential for the proper management of a pool. Knowledgeable and skilled staff are also essential to minimise the risks associated with poor pool water quality. The staff monitoring and training guides 2.2 and 2.3 should be implemented.

2.5.2.1 Event – Particulate pollution not removed

Particulate pollution that is not removed creates a high level of risk and likely to result in hazards, such as microorganisms present (for example, *Giardia* and *Cryptosporidium*), poor pool water quality, bather comfort compromised, increased chlorine demand, and greater potential for the creation of chloramines. The consequences of the event, and therefore the level of risk, will be influenced by the quality of the pool water and the effectiveness of treatment processes, filtration, and disinfection. These are shown in table 13.

Table 13 – Risk information – Particulate pollution not removed with flocculation

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Dosing rates set incorrectly or inappropriately, incorrect chemical used	Make sure chemical to be used is correct Make sure that chemical dosing is appropriate for the filter type and its operation, that is, a one-off manual dose or continuous automatic dosing	Delivery records Filter performance (pre versus post-filter water quality), adequate dirt removal Post-filter: – clarity – pH – alkalinity	No (or no use of) operations manual for dosing control Elevated turbidity, dirt in filtered water, increased cloudiness in pool	Ensure appropriate written policy documents are understood and complied with Install appropriate dosing control equipment Adjust dose rates
Chemical supply exhausted	Ensure system is in place to highlight when chlorine supply is close to running out Maintain records of chemical use to provide a guide to the length of time each chemical supply is likely to last Maintain a reserve supply adequate to cover the time before resupply	Supply levels of coagulant, flocculant and pH-adjusting chemical Usage rates of coagulant, flocculant and pH-adjusting chemical	Chemical supply exhausted Elevated turbidity and dirt in filtered water	Install alarm system or adequate reminder system Urgently order chemicals Commence record-keeping of chemical use

Table 13 – Risk information – Particulate pollution not removed with flocculation (continued)

Maintenance inadequate	Routine maintenance schedule for the filter and its media Knowledge of media condition Adequate records of filter operation including backwashing	Maintenance log Filter performance (pre versus post-filter water quality), adequate dirt removal (for example, turbidity less than 1.0 NTU after filtration, and less than 2.0 NTU before filter)	Maintenance log not signed off Post filter water quality acceptable	Identify cause of fault and rectify Inspect media quality Start monitoring programme
Operation incorrect	Routine operational schedule for the filter and its media Suitable training/ experience of media filter operation Adequate records of filter operation	Maintenance log Proof of suitable training	Maintenance log not signed off No suitable training evidence	Ensure adequately detailed operations manual is being used Seek suitable training
pH too low (resulting from incorrect control and coagulant reaction)	This cause is covered fully in 2.11 but is included here for completeness			

2.5.3 Contingency plans

If an event does occur despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.5.3.1

The event indicators in table 14 may be a sign of an increased likelihood of *Giardia* and *Cryptosporidium* being present. A list of required actions to cope with this contingency is provided.

Table 14 – Event indicators and contingency actions

Indicators	Post filter/pool water cloudiness (high turbidity of filtered water) Advice from public health units of elevated occurrences of giardiasis or cryptosporidiosis reported in the community
Required actions	Immediately close the pool to the public until water of acceptable quality can again be supplied Identify the cause of inadequate filtration and rectify Restart plant operation Record the cause of the failure and the corrective steps taken Review the pool PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.5.4 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 15 provides detailed information for checking filtration events.

Table 15 – Filtration with flocculation assessment

What to measure or observe	Pre and post filter water quality
How often	As required
What to do with the results	Remedy with reference to 1.4 Record results to meet requirements of this Standard or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to public health arising from this pool water quality element Should this review show any unusual incidents, identify where proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality has occurred, then review the procedures for managing the filter Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to the filter are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.5.5 Risk summary

The event creating the greatest risk in media filtration with flocculation is poor removal of particles/ particulate pollution.

The most important preventive measure is to make sure media filter maintenance and operation can be controlled to match the changing pool water quality, and that the chemicals used are suitable and correctly dosed.

Monitor the pH of the treated water, using properly calibrated pH equipment – colour standards or meter and probe (see 2.11).

2.6 Risk management guide – Pre-coat filtration

2.6.1 Introduction

Media filtration is used to remove suspended particles down to about 5 microns in diameter. This filtration will remove microorganisms like *Giardia* and potentially *Cryptosporidium*, and will capture dirt and material introduced during general use of the pool. By reducing contaminants, the disinfection systems can work more effectively.

As this filtration mode will not remove all microorganisms, other forms of additional protection are frequently used; for example, primary disinfection (chlorination); secondary disinfection (for example, UV irradiation, ozone, chlorine dioxide); filtration able to remove smaller particles (pre-coat filtration or flocculation with media filtration); pool use/bather control through education, showers for pre-pool use.

2.6.1.1

If an event occurs during the pre-coat filtration process (that is, the process doesn't work properly), any of the following could result:

(a) If particulate pollution is not removed, there could be high chlorine demand, disinfection is compromised, and microorganisms survive;

(b) If particles are not removed, water becomes cloudy, pool use becomes unpleasant;

(c) If pollution is not removed, disinfection by-products such as chloramines are formed making pool use uncomfortable.

2.6.1.2

Several factors influence the efficacy of the pre-coat filtration process:

(a) Pool water use;

(b) Water quality;

(c) High use or high dirt load, which can rapidly clog the filters and require more frequent back-washing before the particulate pollution makes its way through the filter; and

(d) Pre-coat media of the correct grade properly applied and maintained.

2.6.2 Risk information table

Reliable information about water quality is essential for the proper management of a pool. Knowledgeable and skilled staff are also essential to minimise the risks associated with poor pool water quality. The staff monitoring and training guides in 2.2 and 2.3 should be implemented.

2.6.2.1 Event – Particulate pollution not removed

This creates a high level of risk and is likely to result in hazards such as microorganisms present (for example, *Giardia* and *Cryptosporidium*), poor pool water quality, bather comfort compromised, increased chlorine demand, and greater potential for the creation of chloramines. The consequences of the event, and therefore the level of risk, will be influenced by the quality of the pool water and the effectiveness of treatment processes, filtration, and disinfection. These are expressed in table 16.

Table 16 – Risk information – Particulate pollution not removed with pre-coat filtration

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Maintenance inadequate	Routine maintenance schedule for the filter and its pre-coat media Knowledge of media condition Adequate records of filter operation including backwashing	Maintenance log Filter performance (pre versus post-filter water quality), adequate dirt removal Post-filter: – clarity – pH – alkalinity Turbidity less than 1.0 NTU after filtration, and less than 2.0 NTU before filtration	Maintenance log not signed off Post filter water quality acceptable	Identify cause of fault and rectify Inspect pre-coat media quality Start monitoring programme
Operation incorrect	Routine operational schedule for the filter and its pre-coat media Suitable training/ experience of pre-coat media filter operation Adequate records of filter operation Maintain a sufficient reserve supply or pre-coat media Avoid drop-coating pressure filters (that is, deliberately re-applying used media to a filter) (see note)	Maintenance log Proof of suitable training – especially the time pre-coat is circulated through the filter before it is brought back online Pre-coat media grade Pre-coat media usage	Maintenance log not signed off No suitable training evidence Pre-coat media supply exhausted	Ensure adequately detailed operations manual is being used Seek suitable training Have system in place to ensure pre-coat media supply adequately maintained
Ruptured septum	Routine inspection and maintenance schedule	Soundness of the septum (visual inspection) Pressure change across the filter	Reduced clarity in pool water Pressure change unusual	Replace the septum

Table 16 – Risk information – Particulate pollution not removed with pre-coat filtration (continued)

Loss of pre-coat media	Prevent coat dropping or cracking by operating continuously and avoiding pressure drops Ensure appropriate procedure for restart should coat drop. Use filtered water to apply the pre-coat	Particulate pollution Dirt/turbidity in water leaving the filter Pressure drop across the filter Operational down-time (leads to pressure drops)	Elevated dirt, and reduced clarity in filtered water Abnormally low pressure drop across the filter Long periods of down-time which may result in loss of coat	Drop coat (permissible at start up only) and begin cycle from pre-coat (see note) Review operating procedures to prevent pressure drop Ensure continuous operation Review operations manual
NOTE – There is a risk of accumulated dirt being sent back to the pool if the filter is not coated properly before being put back online.				

2.6.3 Contingency plans

If an event does occur despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.6.3.1

The event indicators in table 17 may be a sign of an increased likelihood of *Giardia* and *Cryptosporidium* being present. A list of required actions to cope with this contingency is provided.

Table 17 – Event indicators and contingency actions

Indicators	Post filter/pool water clarity (high turbidity of filtered water) Cases of giardiasis and cryptosporidiosis are reported in the community
Required actions	Immediately close the pool to the public until water of acceptable quality can again be supplied Identify the cause of inadequate filtration and rectify Restart plant operation Record the cause of the failure and the corrective steps taken Review the pool PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.6.4 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 18 provides detailed information for checking filtration events.

Table 18 – Pre-coat media filtration assessment

What to measure or observe	Pre and post filter water quality
How often	As required
What to do with the results	Remedy with reference to 1.4 Record results to meet requirements of this Standard or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to public health arising from this pool water quality element Should this review show any unusual incidents, identify where proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality has occurred, then review the procedures for managing the pre-coat filter Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to the pre-coat filter are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.6.5 Risk summary

The event creating the greatest risk in pre-coat filtration is poor removal of particles/ particulate pollution.

The most important preventive measure is to ensure pre-coat filter maintenance and operation can be controlled to match the changing pool water quality.

2.7 Risk management guide – Chlorine disinfection

2.7.1 Introduction

Chlorine is used to disinfect, or oxidise contaminants in, pool water. Unlike drinking water, chlorine is continuously challenged by changing water quality from pool use. This section is concerned only with using chlorine as a disinfectant. Compliance with Part 1 will minimise the risks identified in this guide.

Chlorine is added mainly to provide a residual concentration in the pool water to control levels of microorganisms introduced through pool use. Correct application of the chlorine C.t value together with optimised filtration will control *Giardia*, but for all practical purposes chlorine used in isolation is ineffective against *Cryptosporidium*, so removal is dependent on optimised filtration. If there is a problem in keeping the chlorine concentration high enough, for example because of pool use, the chlorine concentration can be boosted or the pool use can be controlled. Additional stress on the disinfection process occurs when there are faecal accidents. The additional actions recommended for these events are covered in Appendix A.

2.7.2 Low chlorine level

If the chlorine level (FAC) isn't high enough, the following could happen:

(a) Microorganisms may cause sickness;

(b) Pool use becomes unpleasant.

2.7.3 High chlorine level

If the chlorine level (FAC) is too high, the following could occur:

(a) Pool users may be harmed;

(b) Clothing damage may occur;

(c) Pool use becomes an unpleasant experience.

2.7.4 Operational considerations

Handling and storage of chlorine (from either gas, liquid or solid chemicals) can present risks to the health of treatment plant staff. These are acknowledged, but are not discussed further as such risks are the subject of the Health and Safety in Employment (HSE) Act, and the HSNO Act.

The chlorination process and the risks associated with it cannot be viewed in isolation. This guide only considers the chlorination of the pool water. Chlorine's value as a disinfectant, and what happens when chlorine is added to water, is also affected by the pool use and bather activities.

If the whole chlorination process is going to work as well as possible, all the following factors, which influence the effectiveness of chlorine disinfection have to be taken into consideration:

(a) Whether the chlorine dose is large enough for other substances in the water to react with the chlorine and still leave enough FAC to disinfect the water effectively;

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(b) pH of the water; this affects how much of the chlorine is in a form that is effective in killing microorganisms (see 2.11);

(c) Water temperature;

(d) Turbidity (mainly due to dirt) of the water when the chlorine is added can hinder the access of chlorine to microorganisms.

2.7.5 Risk summary

The event creating the greatest risk involving chlorinating pool water is not having enough free available chlorine (FAC) to kill microorganisms (pathogenic microorganisms) in the water. However, the pool water treatment system adds chlorine to the water prior to the water entering the pool tank and so this residual chlorine has to be sufficient at all times, prior to, during, and after pool use.

The most important preventive measures are to:

(a) Monitor the process to be sure there is enough FAC in the water, regardless of how the pool use might change;

(b) Ensure sufficient observations are made and records are kept to ensure the chlorine supply does not run low;

(c) Monitor the pH of the treated water, using properly calibrated pH equipment – colour standards or meter and probe.

2.7.6 Risk information tables

Chlorine demand is the difference between the amount of chlorine added to pool water and the FAC residual remaining after the chlorine has reacted with other substances in the water. If the chlorine demand of the pool water increases without an increase in the dose, too little active disinfectant will remain to disinfect the water properly.

2.7.6.1 Event – Microorganisms introduced during pool use

Microorganisms introduced during pool use will very likely lead to elevated chorine demand in order to control the germ population. The consequences of the event, and therefore the level of risk, will be influenced by the pool use and the effectiveness of treatment processes prior to the chlorination process. See table 19.

Table 19 – Risk information – Microorganisms introduced during pool use

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Microorganisms introduced into the water during use: swimming, soaking, wash-down water	Education of pool users, pre-swim showering encouraged, wash-down water to be directed to waste and not into the pool water, reduce access to animals (dogs, birds, other wildlife)	Microbiological water quality unacceptable Chlorine demand	Indicator bacteria detected in a 100 mL sample	Bather control Disinfection of the water

2.7.6.2 Event – Insufficient free available chlorine

A pool that has insufficient free available chlorine has an associated very high risk level as the control of microorganisms will almost certainly be compromised, leading to increased infection rates for pool users. See table 20.

Table 20 – Risk information – Insufficient free available chlorine (inadequate disinfection)

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Automatic-dosing/pump malfunction (see 2.12)	Routine maintenance of dose-controller and dosing pump Replacement of controller if suspect Alarm system to warn if FAC concentration incorrect	FAC Microbiological quality Maintenance log	FAC concentration is less than ideal Microbiological water quality unacceptable Water becomes cloudy Maintenance log not signed off	Identify cause of fault and rectify Manually dose with chlorine until controller repaired Replace controller Close down the pool until remedied
Dose pump/ controller's sensor incorrect or incorrectly calibrated. ('Sensor' could relate to manual test results)	Regular manual checks on calibration of sensor, FAC concentration	FAC Microbiological quality Calibration schedule	FAC concentration is less than ideal Microbiological water quality unacceptable Calibration schedule not signed off	Recalibrate controller Close down the pool until remedied
Sunlight depleting chlorine level	Regular FAC checks Ensure adequate iso-cyanuric acid in pool water	Iso-cyanuriuc acid level should be at ideal level	Adequate FAC hard to maintain Iso-cyanuric acid level too low	Boost iso-cyanuric acid level until ideal level achieved

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Table 20 – Risk information – Insufficient free available chlorine (inadequate disinfection) (continued)

High chlorine demand coupled with poor dose control	Ensure that monitoring of the FAC residual is adequate so that chlorine dosing can be adjusted to take account of changes in pool water quality, or use a controller that automatically adjusts the chlorine dose to maintain a satisfactory residual Control bathing load to control level of substances contributing to the chlorine demand of the water Ensure chlorinator is designed to provide enough chlorine to meet the maximum required dose	FAC Microbiological quality Bathing load versus ability of designed water treatment to control introduced pollution	FAC concentration is less than ideal or microbiological water quality unacceptable Bathing load excessive Inadequate FAC even when chlorinator running at maximum setting	Replace dose controller with a more suitable unit Manual monitoring and manual chlorine control during poor water quality episodes Optimise pool use to reduce chlorine demand Replace chlorinator with one with sufficient capacity Install additional treatment, such as ozonation Close down the pool until remedied
Chlorine supply exhausted	Ensure system is in place to highlight when chlorine supply is close to running out Maintain records of chlorine use to provide a guide to the length of time the supply is likely to last Ensure spare chlorine is available at short notice	FAC Chlorine level in chlorine supply Chlorine usage	FAC concentration is less than ideal or microbiological water quality unacceptable Level of chlorine supply drops too low to allow replacement before the container in use runs out	Install alarm system or adequate reminder system Hand-dose chlorine until system can be brought back on line Close down the pool until remedied

Table 20 – Risk information – Insufficient free available chlorine (inadequate disinfection) (continued)

Chlorine concentration in the dosing solution is low because: **– it has decomposed through the solution being old, or exposed to sunlight** **– the chemical used to prepare the solution is of poor quality**	Ensure chlorine solutions are kept dark and cool (hypochlorite chlorination) Check that an adequate FAC level is produced when a new chlorine supply is first brought into use Check quality of salt (brine electrolysis), or chlorinated chemicals used (hypochlorite chlorination)	FAC Storage conditions of chlorine solution Chlorine concentration in solution generated from brine (brine electrolysis) Supplier's certificate of analysis of chemicals used to prepare chlorine dosing solution	FAC concentration is less than ideal or microbiological water quality unacceptable Chlorine solution exposed to sunlight, or allowed to warm, or both No, or low, chlorine level produced in dosing solution No chlorine detectable when solution first prepared Quality of salt inadequate (brine electrolysis)	Increase the chlorine dose Obtain a fresh container of chlorine Replace chlorine dosing solution Increase the chlorine dose Prepare a new brine solution with salt of satisfactory quality (brine electrolysis) Close down the pool until remedied

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Table 20 – Risk information – Insufficient free available chlorine (inadequate disinfection) (continued)

Chlorine supply adequate, but insufficient chlorine reaching dosing point	Install filters to avoid blockage of valves or venturi by particles in the water Routine maintenance of pumps (chlorine solution and venturi booster) (see 2.12) Check quality of salt; insoluble solids may cause blockages (brine electrolysis) Ensure that all lines carrying gas chlorine are properly dried after opening for maintenance to avoid the development of corrosion products and their blocking the gas lines (Seek professional advice) Ensure chlorinator is designed to provide enough chlorine to meet the maximum required dose Ensure adequate pressure for injector venturi by: – good hydraulic design – use of a booster pump	FAC Pump maintenance log Chlorine lines Gas flow meter readings Chlorine solution flow meter readings Supplier's certificate of analysis of salt Chlorinator dose rate specifications	FAC concentration is less than ideal or microbiological water quality unacceptable Injector and chlorine line blockages Dose pump or boost pump failure Gas flow readings insufficient to provide adequate dose Salt contains compounds likely to precipitate and cause blockages Maximum chlorine dose rate that can be delivered too low	Close down the pool until remedied Check filter and unclog or replace Identify cause of pump fault and rectify Prepare fresh brine solution Replace chlorine lines and dry before resealing system Train staff in correct maintenance procedures Replace chlorinator with one with sufficient capacity Establish reason for poor injector pressure and rectify
FAC monitoring samples taken incorrectly or incorrectly recorded (see Part 1)	Provide staff training for sample collection, analysis and record-keeping Develop monitoring schedule and roster	Records of FAC analysis results	Monitoring inaccuracies	Identify shortcomings in staff training and rectify
Method of FAC measurement incorrect, incorrectly calibrated, or analysis reagents have deteriorated	Provide staff training for sample analysis and record-keeping	Records of FAC analysis results	Monitoring inaccuracies	Identify shortcomings in staff training and rectify

Table 20 – Risk information – Insufficient free available chlorine (inadequate disinfection) (continued)

pH too high (resulting in a lower percentage of the FAC existing in its more powerful disinfecting form)	This cause is covered fully in 2.11 but is included here for completeness. See also figure 1, showing how the effectiveness of chlorine as a disinfectant decreases as the pH increases

2.7.6.3 Event – Too much free available chlorine

While too much free available chlorine is a moderate risk, possible hazards include high levels of unpleasant chlorine-combined compounds (such as chloramines or THMs), heavy metals (from corroded fittings), damage (such as bleaching) of bathers' swimwear, and unpleasant conditions for the pool user and attending staff. See table 21.

Table 21 – Risk information – Too much free available chlorine

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Dosing malfunction (see 2.12)	Routine maintenance of dose controller and dosing pumps Replacement of controller if suspect Install an alarm system to identify when FAC concentration is outside designated limits	FAC Examination of maintenance log	FAC concentration is higher than ideal Maintenance log shows frequent maintenance needed Maintenance log not signed off	Identify cause of fault and rectify Replace controller with new unit Close down the pool until remedied
Dose pump/ controller incorrectly calibrated	Regular manual checks on calibration of FAC controller	FAC Calibration schedule	FAC concentration is higher than ideal Calibration schedule not signed off	Recalibrate controller Decrease chlorine dose rate until recalibration Close down the pool until remedied
Dose pump/ controller set-point incorrect, or incorrect dose calculation	Periodic manual checks on FAC concentration, especially during periods of water quality variability Independent check on calculations (especially after a system change when expected dose rates are uncertain)	FAC Dose flow rates and dose calculations	FAC concentration is higher than ideal Frequent calculation errors found by checks Calculation checks not signed off	Adjust controller set-point Recalculate dose rates and change settings Train staff in making dose calculations

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Table 21 – **Risk information – Too much free available chlorine** (continued)

Incorrect test results due to bleaching of DPD test colour	Ensure dilution test sample or TAC test or both performed if FAC suspected of being too high	FAC test	FAC test shows no colour or the colour created quickly disappears	Ensure staff are adequately and suitably trained Consider closing down the pool until remedied
Spillage of chlorine compound into pool water	Train staff in handling and labelling of chemicals	FAC	FAC concentration is higher than ideal FAC test colour quickly disappears, TAC test appears yellow, not red (DPD test method)	Identify the reasons for the spillage and rectify if possible Close down the pool until remedied

2.7.6.4 Event – Excessive formation of chloramines/disinfection by-products

While a low to moderate risk, chlorine-combined chemicals (CAC) and particularly chloramines impact on the pool user by causing eye/respiratory irritation and strong chlorine odour. See table 22.

Table 22 – Risk information – Excessive formation of chloramines/disinfection by-products

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Excessive pool use, pool treatment system unable to cope with bathing load	Controlling pool use, bathing load, bather activities to reduce organic and inorganic pollution	Bathing load, CAC level FAC should not be less than 85% of the TAC	Elevated CAC Strong 'chlorine' odour Eye/respiratory irritation Patrons/staff experiencing drowsiness or feeling faint	Super chlorinate (when pool not in use) Use alternative (stronger) oxidising treatment to reduce CAC formed Dilute pool water Close down the pool until remedied
Secondary disinfectant process (if installed) not working adequately	Ensure correct operation, maintenance of secondary disinfection process Secondary disinfectants include but are not limited to ozone, UV, and chlorine dioxide	CAC levels	CAC levels continue to rise Pool quality (including indoor air quality) unpleasant Patrons/staff experiencing drowsiness or feeling faint	Operation, maintenance of secondary disinfection process(es) acceptable Close down the pool until remedied

2.7.7 Contingency plans

If an event occurs, despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the seriousness of the problem.

2.7.7.1 Event – FAC concentration is lower than minimum acceptable level

FAC concentration lower than the minimum acceptable level may be detected from the indicators provided in table 23. A list of required actions to cope with this contingency is also provided.

Table 23 – Event indicators and contingency actions – Lower FAC

Indicators	There is no detectable chlorine residual concentration
Required actions	Remedy with reference to 1.4 Identify the reason for the failure and rectify Record cause of system failure and steps taken to correct Modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.7.7.2 Event – FAC concentration is very much higher than the highest value

FAC concentration higher than the highest value may be detected from the indicators provided in table 24. A list of required actions to cope with this contingency is also provided.

Table 24 – Event indicators and contingency actions – Higher FAC

Indicators	A major spillage or overdose of chlorine into the pool water Inability to obtain pink colour from DPD chlorine indicator despite high chlorine dose rates. This is important as it shows that chlorine levels are well in excess of those recommended in Part 1. It occurs because very high chlorine levels bleach the pink colour that normally develops in the presence of chlorine Water develops a strongly chlorinous odour Widespread levels of taste and odour complaints, or illness from users
Required actions	Close down the pool until pool water is of acceptable quality Inform the facility manager Identify the reason for the chlorine overdose and rectify Dump an appropriate amount of pool water, or add chemicals to neutralise the chlorine if more appropriate (neutralisation may be required before any water is dumped, anyway) If excessive levels of chlorine are present in the pool monitor water quality until chlorine concentrations are again back to normal operating levels Record cause of system failure and steps taken to correct Review and modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.7.8 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 25 provides the detailed information for checking chlorination events.

Table 25 – Chlorination assessment

What to measure or observe	FAC Indicator bacteria concentrations Remedy with reference to 1.4 NOTE – The presence of faecal indicators may be influenced by factors other than the adequacy of the chlorination process (for example, faecal accident). The presence of coliforms shows that disinfection is not killing all bacteria.
How often	For the monitoring frequency for indicator bacteria measurements, see Part 1
What to do with the results	Record results to meet requirements of Part 1, or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this pool water quality element are developing. This should be undertaken as frequently as the manager responsible considers necessary to minimise risk to public health Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results or show that poor water quality is reaching users, then review the procedures for managing chlorination Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example preventive measures are up to date; the contingency plan steps are still adequate, and changes to the treatment processes are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.8 Risk management guide – Chlorine dioxide disinfection

2.8.1 Introduction

Chlorine dioxide (ClO_2) treatment is used to disinfect, or oxidise contaminants in water. Chlorine dioxide's effectiveness is not affected by the normal pool pH range and is a more effective oxidant that chlorine but can be used in conjunction with chlorine to enhance the performance of chlorine. It is a very effective bacterial and viral disinfectant and also effectively deactivates the chlorine-resistant pathogens *Giardia* and *Cryptosporidium.*

Chlorine dioxide does not react with ammonia but does react with the phenol ring structured organic compounds in water that are unaffected by chlorine. Chlorine dioxide does not produce disinfection by-products such as haloforms but under some circumstances can produce elevated levels of chlorites and chlorates which will remain in solution and can build-up with time.

2.8.2 Inaccurate operation

If the chlorine dioxide treatment process doesn't work properly, the following could happen:

(a) If there is not enough chlorine dioxide, microorganisms can cause sickness;

(b) If there is too much chlorine dioxide, sickness can come from either the high chlorine dioxide concentration or from chlorine dioxide by-products;

(c) High concentrations of by-products from chlorine dioxide treatment can potentially cause sickness, even when the chlorine dioxide levels are acceptable.

2.8.3 Operational considerations

Although chlorine dioxide is available as a stabilised solution its efficacy (which varies from brand to brand) must be proven before it is considered for use in pools. Normally chlorine dioxide is produced by on-site generation (automatically mixing chlorine or sometimes acid with sodium chlorite). Most modern generation systems are safe but the generator can present risks to the health of treatment plant staff. These are acknowledged, but are not discussed further as such risks are subject to the Health and Safety in Employment (HSE) Act and the HSNO Act.

The chlorine dioxide disinfection process and the risks associated with it cannot be viewed in isolation. This guide considers only the addition of chlorine dioxide to pool water. Chlorine dioxide's value as a disinfectant is also affected by elements of pool water quality and when used in conjunction with chlorine a number of complex chemical relationships need to be taken into account.

The following factors influence the efficacy of the disinfection process in pool water and to optimise performance all these factors have to be taken into consideration:

(a) The chlorine dioxide concentration;

(b) How long the chlorine dioxide has been in contact with the pool water;

(c) Water temperature;

(d) Turbidity of the water/dirt load (this can consume the chlorine dioxide and potentially lead to high levels of chlorite);

(e) Whether used as a sole disinfectant or in combination with chlorine;

(f) Variable bather loads;

(g) Pool hydraulic characteristics.

Chlorine dioxide's main advantages are that its effectiveness is not affected by the normal pool pH range, it is a more effective oxidant that chlorine and can be used in conjunction with chlorine to enhance the performance of chlorine, and is effective against *Giardia* and *Cryptosporidium* if used according to recognised guidelines.

2.8.4 Risk summary

The event creating the greatest risk involved in the chlorine dioxide treatment of pool water is not having enough chlorine dioxide in the water to kill the microorganisms.

The most important preventive measures are:

(a) Monitor the process to be sure there is enough chlorine dioxide in the water, to match the changing quality of the in-pool water;

(b) Install an alarm on the supplies of chemicals used for chlorine dioxide generation to provide an alert when the supplies are running low. Maintain records to keep aware of when this might happen; always have spare supplies on hand;

(c) Manage the variable chlorine dioxide demand in relation to variable pool bathing loadings.

2.8.5 Risk information table

Reliable information about water quality is essential for the proper management of pool water quality. A low chlorine dioxide concentration will result in a high level hazard because germs will not be killed. This applies regardless of whether it is used as a sole disinfectant or in conjunction with chlorine. The consequences of the event, and therefore the level of risk will be influenced by the pool use. The effectiveness of treatment processed prior to the addition of chlorine dioxide will have a significant effect on the effectiveness of chlorine dioxide.

NOTE – This PRMP assumes chlorine dioxide generation through the chlorine-chlorite process and assumes that chlorine dioxide will be used as the sole disinfectant and or in conjunction with chlorine. If conjunctive use is applicable then the FAC concentration in the pool water will normally be lower than for situations when chlorine is the sole disinfectant.

2.8.5.1 Event – Chlorine dioxide concentration too low

Low chlorine dioxide concentration levels have an associated high risk, as this will result in microorganisms not being killed, and possible elevated levels of chlorite. This will be influenced by the quality of the source water and the effectiveness of treatment processes prior to chlorine dioxide treatment. See table 26.

Table 26 – Risk information – Chlorine dioxide (ClO_2) concentration too low

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Dosing malfunction – either dosing pumps or controller	Routine controller and dosing pump maintenance Replacement of controller if suspect Alarm system to warn if ClO_2 residual concentration is incorrect	ClO_2 residual concentration Microbiological quality Maintenance log	Low ClO_2 residual concentration (see Appendix H) Non-compliant microbiological results (see table 4) Frequent repair needed Maintenance log not signed off	Identify cause of fault and rectify Convert to chlorine dosing until repaired Increase microbiological testing frequency Replace controller or dosing pumps
Dosing controller's sensor incorrect	Regular manual checks or calibration of the controller	ClO_2 residual concentration Microbiological quality Schedule for calibration/ check on sensor performance	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4) Calibration schedule not signed off	Recalibrate controller sensor Increase ClO_2 dose rate until recalibration undertaken
Dosing controller's set-point incorrect or incorrect dose calculation	Periodic manual checks on ClO2 residual concentration, especially during periods of water quality variability Independent check on calculations (especially after a system change when expected dose rates are uncertain) Install visual flow indicators to allow flow to be checked by eye	ClO_2 residual concentration Flow rates Dose flow rates Dose calculations	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4) Frequent calculation errors found Calculation checks not signed off Flow rates lower than expected	Adjust or recalibrate controller set-point Recalculate dose rates and change settings Train staff in making dose calculations

Table 26 – Risk information – Chlorine dioxide (ClO_2) concentration too low (continued)

High ClO_2 demand coupled with poor dose control	Ensure that monitoring of the ClO_2 residual concentration is adequate so that ClO_2 dosing can be adjusted to take account of changes in water quality, or use a controller that automatically adjusts the ClO_2 dose to maintain a satisfactory residual concentration Upstream processes removing substances contributing to the ClO_2 demand from the water Ensure ClO_2 generator can deliver the maximum required dose rate	ClO_2 residual concentration High CAC	Low ClO_2 residual concentration or non-compliant microbiological results (see table 4) during periods of poor water quality CAC consistently high Inadequate ClO_2 residual concentration even when generator running at maximum	Replace dose controller with more suitable unit Manual monitoring and manual ClO_2 control during poor water quality such as from high bather loads Optimise up-stream processes to better reduce ClO_2 demand Replace generator with one with sufficient capacity
Power failure	Stand-by generator or battery bank Alarm system to alert for change to chlorine dosing system	Electricity supply	Poor continuity of power supply	Refuel generator (if appropriate) Procedures in place for change to chlorine-only system
ClO_2 supply exhausted	Place alarm on supply of chemicals for ClO_2 generation to indicate when a supply is close to running out Maintain records of ClO_2 use to provide a guide to the length of time the chlorine and chlorite supplies are likely to last Ensure spare supplies of chemicals are always kept on site	ClO_2 residual concentration ClO_2 usage Levels of generation chemicals	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4) Level of ClO_2 generation chemicals too low to allow replacement before they run out	Install alarm system Hand-dose chlorine or initiate procedures for chlorine only dosing systems until system can be brought back on line

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Table 26 – Risk information – Chlorine dioxide (ClO_2) concentration too low (continued)

ClO_2 generator malfunction	Preventive maintenance programme Soften the water used to make up the sodium chlorite solution to avoid clogging by scale (if water is hard)	ClO_2 residual concentration Maintenance log	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4) Frequent repairs needed	Identify cause of fault and rectify Dose with chlorine until system can be brought back on line Clear scale from lines and valves
ClO_2 generation chemistry not optimised (wrong chlorine and chlorite ratio, concentrations, or pH); chemicals of unsatisfactory quality; or wrong chemicals used	Carry out pilot tests to determine optimum chemical feed rates for ClO_2 production Check chemical flows are correctly set; pH set point is correct Ensure chemicals are of adequate quality. Obtain manufacturer's certification Ensure chemical storage containers are properly labelled and an operator is present to supervise delivery	ClO_2 residual concentration Supplier's certificate of analysis for chemicals used	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4) Unsatisfactory chemical quality	Modify chemical feed rates until ClO_2 production maximised Change chemical supplier Require chemical supplier to only deliver when the operator is present
ClO_2 supply adequate, but insufficient ClO_2 reaching dosing point	Routine maintenance of pumps dosing ClO_2 solution Pump capacity too low to meet maximum ClO_2 demand	ClO_2 residual concentration	Low ClO_2 residual concentration Injector blockages Pump failure Inadequate pump specifications	Identify and rectify causes of pump failure Obtain a new pump
Exposure to sunlight resulting in photo-decomposition of ClO_2	Ensure ClO_2 dosing solution is protected from sunlight	ClO_2 residual concentration	Low ClO_2 residual concentration Non-compliant microbiological results (see table 4)	Cover open channels or reticulate in pipes
ClO_2 monitoring samples taken incorrectly or incorrectly recorded	Provide staff training for sample analysis and record-keeping Develop monitoring schedule and roster	Analyse records	Independent checks show monitoring inaccuracies	Identify staff training needs and provide training

Table 26 – Risk information – Chlorine dioxide (ClO_2) concentration too low (continued)

Method of ClO_2 measurement incorrect, incorrectly calibrated, or reagents used in analysis have deteriorated	Provide staff training for sample analysis and record-keeping	Analyse records	Independent checks show monitoring inaccuracies	Identify staff training needs and provide training
NOTE – Chlorine dioxide demand is the difference between the amount of chlorine dioxide added to the water and the chlorine dioxide residual concentration remaining after the chlorine dioxide has reacted with other substances in the water. If the chlorine dioxide demand of the water increases without an increase in the dose, too little disinfectant will remain to disinfect the water properly.				

2.8.5.2 Event – Chlorine dioxide concentration too high

While a too high concentration of chlorine dioxide is a low to moderate risk, possible hazards include high levels of unpleasant chlorine-combined compounds, damage (such as bleaching) of bathers' swimwear, and unpleasant conditions for the pool user and attending staff. See table 27.

Table 27 – Risk information – Chlorine dioxide (ClO_2) concentration too high

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Dosing malfunction	Routine controller and dosing pumps maintenance Replacement of controller if suspect Fit an alarm to indicate incorrect ClO_2 concentration	ClO_2 residual concentration Maintenance log	ClO_2 residual concentration is high Frequent repair needed Maintenance log not signed off	Identify cause of fault and rectify Replace controller with new unit
Dosing controller's sensor incorrectly set up	Regular manual checks on controller results	ClO_2 residual concentration	ClO_2 residual concentration is high Sensor check or calibration schedule not signed off	Check controller sensor Manually monitor and adjust ClO_2 dose rate until recalibration undertaken

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Table 27 – Risk information – Chlorine dioxide (ClO_2) concentration too high (continued)

Dosing controller's set-point incorrect or incorrect dose calculation	Periodic manual checks on ClO_2 concentration, especially during periods of high pool loading Independent check on calculations (especially after a system change when expected dose rates are uncertain) Install visual flow indicators to allow flow to be checked by eye	ClO_2 residual concentration Flow rates Dose calculations	ClO_2 residual concentration too high Frequent calculation errors found by checks Calculation checks not signed off Flow rates below expected values	Adjust controller set-point Recalculate dose rates and change settings Train staff in making dose calculations
Low ClO_2 demand coupled with poor ClO_2 dose control	Use a control method that links dose control to ClO_2 residual concentration at appropriate location	ClO_2	ClO_2 residual concentration too high	Replace dose controller with more suitable unit Manual monitoring and manual ClO_2 control when pool loading variable
ClO_2 solution strength from generator too high	Check that a satisfactory ClO_2 concentration is produced when new supply of chemicals for generation is first brought into use	ClO_2 ClO_2 level in the ClO_2 solution	ClO_2 residual concentration is too high ClO_2 concentration in dosing solution is too high	Determine the cause of the high ClO_2 concentration and rectify Provide training in the preparation of solutions (including calculations)

2.8.5.3 Event – Excessive formation of by-products

The excessive formation of by-products from high concentrations of chlorine dioxide is a moderate risk. See table 28.

Table 28 – Risk information – Excessive formation of by-products

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
ClO_2 generation chemistry not optimised (wrong chlorine and chlorite ratio, concentrations, or pH)	Carry out pilot tests to determine optimum chemical feed rates for ClO_2 production Checks to ensure chlorite solution concentration is correct Provide staff training in chlorite solution preparation	Chlorite Chlorate	Elevated levels of chlorite and chlorate	Modify chemical feed rates until ClO_2 production maximised, and by-products minimised Identify staff training needs and provide training
Natural organic matter present in the water being chlorinated (reduction of ClO_2 to chlorite)	Provision of treatment processes upstream to reduce levels of organic matter in the water. (For example showering prior to pool use)	CAC	Elevated CAC Elevated chlorite formation	Optimise treatment parameters in upstream processes to maximise removal of organic matter Improve control over bather activities

2.8.6 Contingency plans

If an event happens despite preventive and corrective actions, the pool manager may need to be consulted to assess the degree of seriousness.

2.8.6.1 Event – ClO2 concentration is lower than minimum effective level

Low ClO_2 concentration may be detected from the indicators provided in table 29. A list of required actions to cope with this contingency is also provided.

Table 29 – Risk information – ClO_2 concentration low

Indicators	A detectable ClO_2 residual concentration cannot be obtained in the pool water or post generator Non-compliant microbiological results (see table 4) Illness in the community linked to the pool
Required actions	Follow the actions given in Part 1 Initiate or enhance the chlorine dosing system to increase the chlorine concentration as an interim measure Identify the reason for the failure and rectify Record cause of system failure and steps taken to correct Modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.8.6.2 Event – ClO2 concentration is higher than maximum acceptable level

Higher than the maximum acceptable ClO_2 concentration may be detected from the indicators provided in table 30. A list of required actions to cope with this contingency is also provided.

Table 30 – Risk information – ClO_2 concentration high

Indicators	Knowledge of a major overdose of ClO_2 into the water Inability to obtain pink colour from DPD indicator despite high ClO_2 dose rates NOTE – This indicates high ClO_2 levels – very high ClO_2 levels bleach the pink colour that normally develops in the presence of ClO_2. Change in the odour, colour, or taste of the water Widespread levels of taste and odour complaints, or illness, in the community
Required actions	Close down the plant. Consider draining, diluting or neutralising the high chlorine dioxide level in the pool Identify the reason for the ClO_2 overdose and rectify Record cause of system failure and steps taken to correct Modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.8.6.3 Event – Chlorate or chlorite concentrations higher than 3 mg/L

High chlorate or chlorite concentrations may be detected from the indicators provided in table 31. A list of required actions to cope with this contingency is also provided. Refer to World Health Organization: *Guidelines for safe recreational waters* Volume 2.

Table 31 – Risk information – High chlorate or chlorite concentrations

Indicators	Chlorite concentration higher than 3 mg/L Chlorate concentration higher than 3 mg/L
Required actions	Decrease the ClO_2 dose, and monitor microbiological determinants to ensure that reduction in the ClO_2 has not led to inadequate disinfection. The ClO_2 dose should still meet the C.t requirements for *Cryptosporidium* inactivation (see table 32) Record the steps taken to correct the problem Modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.8.7 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 32 provides the detailed information for checking chorine dioxide events.

Table 32 – Chlorine dioxide assessment

What to measure or observe	ClO_2 concentration Microbiological quality (see table 4) Chlorite and chlorate Chlorine dioxide generation rate NOTE – The presence of faecal indicators may be influenced by factors other than the adequacy of the chlorine dioxide process. For example chlorine dioxide is not in contact with water long enough, a faecal incident or high and or variable bathing loads.
How often	For the monitoring frequencies for microbiological quality, see Part 1
What to do with the results	Results need to be recorded to meet the requirements of Part 1 and to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this pool water quality element are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to public health Should this review show any unusual incidents, indicate that proper procedures are not being carried out, highlight poor laboratory results or indicate that poor water quality is reaching users, then review the procedures for managing chlorine dioxide treatment Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to the treatment processes are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.9 Risk management guide – Ozone disinfection

2.9.1 Introduction

Ozone is used as a secondary disinfectant to disinfect or oxidise contaminants in pool water. Ozone is a poisonous gas, and if it is not properly stripped from the water before recirculation, the off-gassing of ozone is a potential hazard to the health of bathers.

The onsite generation and use of ozone can present risks to the health of treatment plant staff. These are acknowledged, but are not discussed further as such risks are the subject of the Health and Safety in Employment (HSE) Act, and the HSNO Act.

2.9.1.1 Value of ozone as a disinfectant

Ozone's value as a disinfectant is affected by elements of pool water, therefore the ozonation process and the risks associated with it cannot be viewed in isolation. Ozone does not last long in water. The primary disinfectant, chlorine, which has a longer lifetime, has to be added after ozone to kill any microorganisms that enter the pool water during use. Under optimum conditions ozone will destroy protozoa such as *Giardia* and *Cryptosporidium*.

This guide considers only the ozonation of the pool water.

2.9.1.2 Failure of ozonation process

If an event occurs during ozonation (that is, the process doesn't work properly), either of the following could occur:

(a) If there is not enough ozone added to the water, microorganisms can cause sickness;

(b) Unacceptable aesthetic water quality may result in bather discomfort.

The following factors influence the efficacy of the disinfection process and to optimise performance, all these factors have to be taken into consideration:

(c) Ozone concentration;

(d) The period of time the ozone is in contact with the water;

(e) Water temperature;

(f) Turbidity of the water/dirt load due to pool use prior to when the ozone is added to it can hinder the access of ozone to microorganisms.

2.9.2 Risk summary

The events creating the greatest risks involved in ozonation of pool water are:

(a) Insufficient ozone in the water during the contact period in the treatment stage to kill microorganisms; and

(b) Inadequate ozone stripping after the contact period allowing public contact with the ozone (see table 33).

The most important preventive measures are to:

(c) Monitor the process to be sure there is enough ozone dosed into the water at the contact stage of treatment, regardless of how the quality of the incoming pool water might change;

(d) Install an alarm on the ozone generator to provide an alert if the generator fails;

(e) Identify causes, preventive measures and so on, for the event of ozone not being stripped from the water that is being returned to the pool.

2.9.3 Risk information table

A low ozone concentration will result in a high level hazard because microorganisms will not be killed. The consequences of the event, and therefore the level of risk, will be influenced by the pool use, the effectiveness of treatment processes prior to the ozonation process, and whether a residual disinfectant is added to the water following ozonation.

Ozone will also control combined chlorine levels as well as other chlorine-demanding substances. If ozone levels are less than expected, chlorine demand will increase and therefore FAC levels will have to be monitored more closely.

2.9.3.1 Event – Ozone level too low

A low ozone concentration will result in a high level hazard because microorganisms will not be killed. See table 33.

Table 33 – Risk information – Low ozone level in treatment stage

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Ozonator or dosing controller malfunction	Routine maintenance Replacement of controller if suspect Alarm system to warn of inadequate ozone concentration Ensure air used as the feed gas is properly dried before injection into the generator	Microbiological quality Ozone concentration after contact period Maintenance log Humidity of air entering generator	Low ozone residual (see Appendix D3) Microbiological water quality unacceptable Ozonator or controller failure Frequent maintenance needed Maintenance log not signed Water vapour levels in feed gas above those recommended by the manufacturer	Identify cause of fault and rectify Observe and maintain FAC levels until repaired Replace ozonator or controller Identify reason for air drier not working, and rectify Close down the pool until remedied
Dosing controller's sensor incorrectly calibrated, ozone level delivered inaccurate	Regular manual checks on calibration of sensor (refer to the manufacturer's specification)	Microbiological quality Ozone concentration after contact period Calibration log	Low ozone residual (see Appendix D3) Microbiological water quality unacceptable Calibration schedule not signed off	Re-calibrate sensor Increase ozone dose rate until re calibration undertaken Close down the pool until remedied
Ozone monitoring samples taken incorrectly, or incorrectly recorded (see 2.2)	Provide staff training in sample collection analysis and record-keeping Develop monitoring schedule and roster	Analyse records	Audits show monitoring inaccuracies	Identify staff training needs and provide training
Method of ozone measurement incorrect, incorrectly calibrated, or analysis reagents have deteriorated	Provide staff training in sample collection analysis and record-keeping	Analyse records	Audits show monitoring inaccuracies	Identify staff training needs and provide training Close down the pool until remedied

2.9.4 Contingency plans

If an event does occur, despite preventive and corrective actions you have taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.9.4.1

When ozone concentration falls below the minimum acceptable level, the event may be detected from the indicators provided in table 34.

Table 34 – Event indicators and contingency actions

Indicators	A detectable ozone residual cannot be obtained in the water at the outlet of the contact tank, or the disinfectant used to provide a disinfecting residual cannot be detected in the water leaving the treatment plant
Required actions	Follow the actions provided in Part 1 Increase chlorine dose rates into the post-treatment pipework until the disinfecting systems are operational again Identify the reason for the failure and rectify Record cause of system failure and steps taken to correct Review and modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.9.5 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 35 provides the detailed information for checking ozonation events.

Table 35 – Ozonation assessment

What to measure or observe	FAC (A low or absent FAC concentration may identify the failure of the ozonation system, but there may be other explanations and these should also be checked) Ozone generation rate Indicator bacteria concentrations (see 1.4) NOTE – The presence of faecal indicators may be influenced by factors other than the adequacy of the ozonation process (for example, a faecal accident). The presence of coliforms identifies that disinfection is not killing all bacteria.
How often	For the monitoring frequency for indicator bacteria measurements, see Part 1
What to do with the results	Record results to meet requirements of Part 1, or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this pool water quality element are developing. This should be undertaken as frequently as the manager responsible considers necessary to minimise risk to public health Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality is reaching users, then review the procedures for managing ozonation Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example preventive measures are up to date; the contingency plan steps are still adequate; and changes to the treatment processes are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.10 Risk management guide – Disinfection by ultraviolet irradiation

2.10.1 Introduction

UV is used as a secondary disinfectant to disinfect, or oxidise contaminants in pool water. Therefore UV shall be used in conjunction with chlorine to meet this Standard.

Shining intense ultraviolet (UV) light through pool water (UV irradiation) can be used to disinfect it as well as control some undesirable disinfection by-products like chloramines. Under optimum conditions UV is effective against protozoa such as *Giardia* and *Cryptosporidium*.

This guide is concerned only with using UV light as a secondary disinfectant and treatment for chloramine control, and does not cover the safety of its use.

The use of UV irradiation can present risks to the health of pool staff. These are acknowledged, but are not discussed further as such risks are the subject of the Health and Safety in Employment (HSE) Act.

The action of UV has no long-term effect, therefore the primary disinfectant, chlorine, which has a longer lifetime, must be added after UV treatment to kill any microorganisms that get into the pool water, during use.

If an event occurs during UV irradiation (that is, the UV disinfection process doesn't work properly), the UV dose may be too little to kill microorganisms and stop them from causing sickness, or the level of chloramines becomes elevated and pool use becomes uncomfortable.

The following factors influence the efficacy of UV use:

(a) Intensity and wavelength(s) of the UV delivered: microorganisms are killed fastest by intense light in a particular wavelength range;

(b) Exposure period: the longer microorganisms are exposed to UV light, the higher the percentage that are killed;

(c) Poor water quality and constituents of the water that absorb light or form deposits on lamp surfaces reduce the effectiveness of the light in killing microorganisms. For example suspended material, isocyanuric acid, iron, resulting in poor performance, microorganisms surviving, chloramines not destroyed;

(d) Maintenance of lamps.

2.10.2 Risk summary

The event creating the greatest risk involved in UV irradiation of pool water is the UV dose being too low to kill microorganisms in the water, or control chloramines.

The most important preventive measures are:

(a) Regularly maintain the unit and clean the surface of the lamp, or lamp sleeve, to make sure enough UV light passes into the water;

(b) Use a sensor to measure the UV irradiation;

(c) Install an alarm on the irradiation sensor to provide an alert when the light intensity is too low.

2.10.3 Risk information table

A low UV level will result in a high level hazard because microorganisms will not be killed, and chloramines will not be controlled. The consequences of the event, and therefore the level of risk, will be influenced by the pool use, the effectiveness of treatment processes prior to the UV process, and whether a residual disinfectant is added to the water following UV disinfection.

2.10.3.1 Event – UV level too low

Low UV levels will result in a high level hazard because microorganisms will not be killed, and chloramines will not be controlled. See table 36.

Table 36 – Risk information – Low UV level

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Inadequate UV intensity at the required wavelength	Routine cleaning and maintenance schedule for lamp sleeves and UV sensor Regular replacement of UV lamp The sensor for measuring UV radiant exposure should be on the wall of the irradiation chamber farthest from the UV lamp Lubrication of seal each time the tube is removed (with water-based lubricant) Reduce water hardness to minimise scaling on lamp sleeves and UV sensor lens Link UV sensor to alarm to show inadequate UV intensity	Microbiological quality UV intensity Alarm Signs of scaling on the lamp's quartz sleeve and sensor lens Maintenance records	Microbiological water quality unacceptable Activation of the UV intensity alarm Water inside quartz sleeve (ineffective seal) Scale formation on the quartz sleeve Absence of maintenance records	Clean quartz sleeve and sensor lens Replace UV lamp Relocate sensor, or purchase a unit with correctly located sensor Lubricate sleeve seal Check water hardness and treat to reduce if necessary
Excessive UV-absorbing materials or turbidity/dirt	Ensure the operation of filtration is optimised	Microbiological quality Filter operation and maintenance schedule Turbidity/colour post-filter Pressure drop across the filter (breakthrough or rupture may lead to low pressure drop)	Microbiological water quality unacceptable Excessive dirt/turbidity or UV-absorbing substances (sufficient to reduce the UV intensity to a level that is too low) Absence of maintenance records	Obtain a more suitable filter system

2.10.4 Contingency plans

If an event occurs, despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the seriousness of the problem.

2.10.4.1 Event – UV dose is lower than the minimum acceptable level

A UV dose lower than the minimum acceptance level may be detected from the indicators provided in table 37. A list of required actions to cope with this contingency is also provided.

Table 37 – Event indicators and contingency actions

Indicators	Action required if UV radiant exposure is less than 400 Joule per square metre (J/m^2) at 240 – 290 nm Illness reported by pool users
Required actions	Immediately take the UV plant offline and increase FAC levels as recommended in Part 1. Then: If excessive turbidity is detected in water after filtration: – identify and rectify cause of inadequate filtration – monitor turbidity until it reaches acceptable limits If excessive colour is detected in water after filtration: – identify and rectify cause of excess colour – monitor colour until it reaches acceptable limits If low UV dose is not due to poor pool water quality: – identify and rectify cause of reduced UV reading at the sensor (low tube output, dirty tube/quartz sleeve, increased flow, and so on) Then, in all above situations if indicator organisms or pathogens have entered the reticulation Restart plant operation Record cause of system failure and steps taken to correct Review and modify the PRMP if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.10.5 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 38 provides the detailed information for checking UV disinfection events.

Table 38 – UV disinfection assessment

What to measure or observe	UV intensity (calculate UV dose) Indicator bacteria concentrations (see 1.4) NOTE – The presence of faecal indicators may be influenced by factors other than the adequacy of the UV treatment process (for example, a faecal accident). The presence of coliforms shows that disinfection is not killing all bacteria.
How often	For the monitoring frequency for indicator bacteria measurements, see Part 1
What to do with the results	Record results to meet requirements of Part 1, or to allow the PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this pool water quality element are developing. This should be undertaken as frequently as the manager responsible considers necessary to minimise risk to public health Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results or show that poor water quality is reaching users, then review the procedures for managing UV treatment Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example preventive measures are up to date; the contingency plan steps are still adequate; and changes to the treatment processes are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.11 Risk management guide – pH adjustment

2.11.1 Introduction

This guide is concerned only with the pH or alkalinity adjustment, or both, and maintenance of pool water. The process described is based on the pool water not meeting the requirements of Part 1.

2.11.1.1

Adjustment of the pH level of pool water during treatment may be needed to:

(a) Make pool water more acceptable to pool users/bathers;

(b) Make disinfection by chlorine (see 2.7) more effective;

(c) Reduce its corrosiveness (aggressiveness) by helping to chemically balance the water.

2.11.1.2

Adjustment of pH can be achieved by:

(a) The addition of acidic solutions to the water;

(b) The addition of alkaline solutions to the water.

2.11.1.3

If an event occurs during pH adjustment (that is, the process doesn't work properly), the following could be experienced:

(a) If the pH level of the water is too high, microorganisms can survive (and possibly cause sickness) because of poor disinfection by chlorine;

(b) If the pH level of the water is too high, eye and skin irritation may occur;

(c) If the pH level of the water is too low, eye and skin irritation may occur;

(d) If the pH level of the water is too low, corrosion may lead to the dissolution of heavy metals resulting in discolouration of the pool water.

2.11.2 Risk summary

The events creating the greatest risks involved in controlling the pH level of pool water is the pH level getting to unacceptable levels – either too high or too low.

The most important preventive measures are:

(a) To regularly check that the pH monitoring (manual tests or automatic controller's sensor) is properly calibrated. For manual testing this means that results are being interpreted correctly;

(b) To ensure that the pH/alkalinity adjusting chemical supply is not allowed to run low.

2.11.3 Risk information table

The moderate level risks of poor pH level control are poor disinfection by chlorine, bather discomfort, microorganisms not killed, and eye/skin irritation.

2.11.3.1 Event – pH level too high

High pH level control can result in bather comfort being compromised, scale formation, and low chlorine efficacy. See table 39.

Table 39 – Risk information – High pH level

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Dosing pump malfunction **(for example, excessive dosing pushing pH too high, or insufficient dosing allowing hypochlorite to raise pH too high)**	Routine controller/ probe and dosing pump maintenance (see 2.12) Replacement of controller if suspect Install an alarm to identify when the pH level has gone outside the intended range	pH Maintenance log	pH level more than 8.0 Frequent repair needed Maintenance log not signed off Problems with chlorination effectiveness – elevation of microbiological levels Bather complaints	Identify cause of fault and rectify Replace controller Close down the pool until remedied
Incorrect calibration of controller's pH probe	Regular checks on pH probe calibration using calibration buffers Training of staff in pH probe calibration	pH Calibration schedule	pH level more than 8.0 Problems with chlorination effectiveness – elevation of microbiological levels Bather complaints	Re-calibrate pH probe Identify staff training needs and provide training Consider closing pool until remedied
Dose rate set incorrectly (manual or automatic)	Monitoring of pH using an independently calibrated pH probe (see 2.12)	pH Calibration schedule	pH level more than 8.0 Problems with chlorination effectiveness	Adjust controller set-point

Table 39 – Risk information – High pH level (continued)

Incorrect chemical used, chemical of poor quality, or dosing solutions prepared at the wrong strength (use of the incorrect chemical includes selection of a chemical which makes pH control more difficult because of its strength and ability to raise the pH very high, very quickly, such as sodium hydroxide (not recommended))	Make sure chemicals supplied are delivered to the correct containers Clearly label containers Operator on site when chemicals delivered Check strength of solutions supplied, and evidence of purity of chemicals supplied System of independent checks on dosing solution preparation Select a pH adjustment chemical that will improve the pH-buffering capacity (alkalinity) of the water, if pH stability is poor	pH Supplier's certificate of analysis Safety data sheets	pH level more than 8.0 Chemical containers not labelled Problems with chlorination effectiveness	Label chemical containers Require supplier to ensure that an operator is present when chemicals are delivered Use chemical(s) that will provide improved buffering (alkalinity) of the water's pH Change supplier Consider closing pool until remedied
Chemical supply adequate, but insufficient chemical reaching the dosing point	Routine maintenance schedule for pumps Routine maintenance schedule to ensure chemical supply lines are not blocked	pH Chemical dose system maintenance schedule	pH level more than 8.0 Problems with chlorination effectiveness Bather comfort compromised	Identify pump fault and repair or replace pump Clear, or replace, blocked chemical feed lines

2.11.3.2 Event – pH Level too low

The low level risk of a too low pH can include bather comfort compromised and corrosion of materials (copper, nickel, brass).

The same causes, preventive measures, checks and corrective actions as noted in table 39 are appropriate here. The minimum pH however, should be no less than 7.2. Problems with disinfection efficacy are not linked to low pH levels.

Further, there is one additional preventive measure required when pH adjustment is by contact with calcite or a dolomitic material (for example, Akdolit) especially if top-up water is 'soft'. See table 40.

Table 40 – Risk information – Low pH level

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Chemical supply exhausted	Regular checks on solid material remaining (if accessible)	Chemically test water	Hardness/ alkalinity levels are lower than usual	Top up solid as required

2.11.3.3 Event – Microorganisms introduced during pool use

Microorganisms introduced during pool use have a low to moderate level of risk, influenced by the efficacy of the current and subsequent disinfection process. See table 41.

Table 41 – Risk information – Introduction of microorganisms during pool use

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Microorganisms introduced into the water during use; swimming, soaking, wash-down water	Education of pool users, pre-swim showering to be encouraged, wash-down water to be directed to waste and not into the pool water, reduce access to animals (dogs, birds, other wildlife, and so on)	Microbiological water quality	Microbiological water quality unacceptable Hardness/alkalinity are lower than usual	Bather control Disinfection of the water

2.11.4 Contingency plans

If an event occurs, despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the seriousness of the problem.

2.11.4.1 Event – pH concentration is higher than the highest value

A concentration of pH higher than the highest value in table 1 may be detected from the indicators provided in table 42. A list of required actions to cope with this contingency is also provided.

Table 42 – Event indicators and contingency actions – High pH

Indicators	pH levels are above the maximum level set by the water supplier NOTE – pH probes (glass electrodes) are recommended to make measurements in pool water. Comparators or colorimeters are too inaccurate. Customer complaints of 'soapy' water, or of chemical burns from water Knowledge of a chemical spillage or overdose that may have led to a high pH water being produced Problems with disinfection efficiency when the pH exceeds the maximum acceptable level (very caustic water may achieve disinfection through the pH level alone, but may injure the pool user)
Required actions	Identify the cause or problem and rectify if necessary Record cause of system failure and steps taken to correct Review the pool PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.11.4.2 Event – pH concentration is lower than the minimum acceptable level

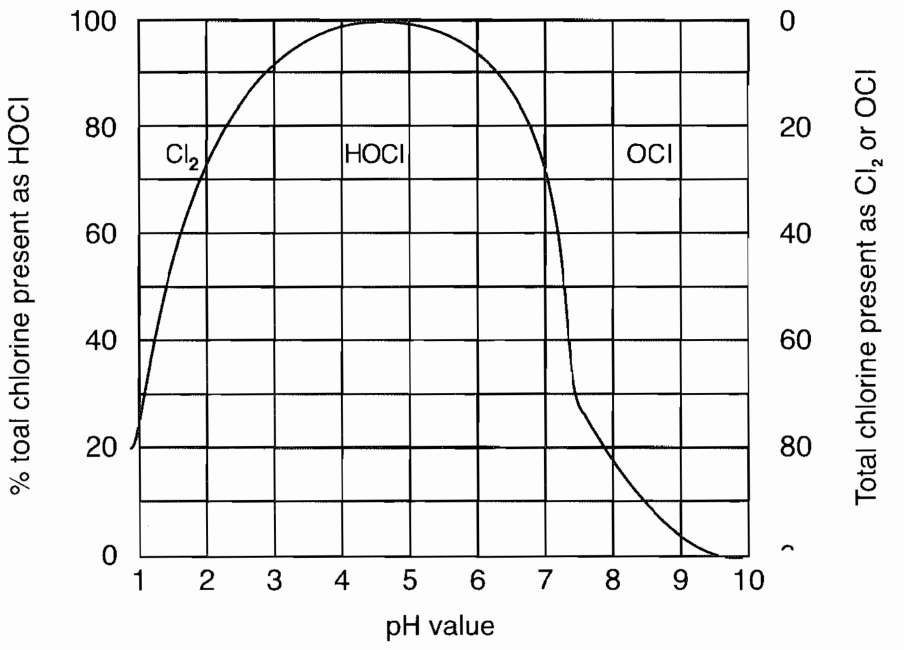
Low pH concentration may be detected from the indicators provided in table 43. A list of required actions to cope with this contingency is also provided.

Table 43 – Event indicators and contingency actions – Low pH

Indicators	pH levels are below the minimum acceptable level in Part 1 NOTE – pH probes (glass electrodes) are recommended to make measurements in pool water. Comparators or colorimeters are too inaccurate. Knowledge of a chemical spillage or overdose that may have led to production of a low pH Customer complaints of a strong metallic taste in the water
Required actions	Inform the public health unit of the situation and close the pool to the public if pH drops below 5 until pool water of acceptable quality can again be supplied Identify the cause or problem and rectify if necessary Raise the pH of the water in the pool until is more than 7, or dump it (raising the pH may be required for this anyway – check on discharge consent or trade waste bylaw) Record cause of system failure and steps taken to correct Review the pool PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.11.4.3 Impact of pH value on disinfection capability

Figure 1 shows the effect of pH on the dissociation of hypochlorus acid. The increase in the pH results in FAC becoming less effective as a disinfectant – 'HOCl' is the more effective disinfectant, while 'OCl' will still disinfect but requires more time to achieve the same while 'Cl_2' is gas chlorine.



Effect of pH on dissociation of hypochlorous acid

Figure 1 – Impact of pH value on disinfection capability

2.11.5 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated. Table 44 provides the detailed information for checking pH level events.

Table 44 – pH level assessment

What to measure or observe	pH Indicator bacteria concentrations Remedy with reference to 1.4 NOTE – The presence of faecal indicators may be influenced by factors other than the adequacy of the chlorination process (for example, faecal accident). The presence of coliforms shows that disinfection is not killing all bacteria.
How often	For the monitoring frequency for indicator bacteria measurements, see Part 1
What to do with the results	Record results to meet requirements of Part 1, or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this pool water quality element are developing. This should be undertaken as frequently as the manager responsible considers necessary to minimise risk to public health Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality is reaching users, then review the procedures for managing chlorination Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example preventive measures are up to date; the contingency plan steps are still adequate; and changes to the treatment processes are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.12 Risk management guide – Pump operation

2.12.1 Introduction

The risk process here is based on the pool water not meeting the requirements of Part 1.

Pumps are used in a number of ways in pool water treatment: moving water to and from the pool, and dosing chemicals. Issues involving dosing pumps used for specific purposes are included in other risk management guides. This guide is concerned with the management and operation of the two main categories of pumps shown in table 45.

Table 45 – Pump types and applications

Pump type	Pump application
Recirculation pumps	Recycles water from the pool via surface skimmers or a balance tank or both, through various treatment stages and back out into the pool. Most commonly there is only one duty pump
Chemical dose pumps	Used to dose chemicals and to pump water to equipment that monitors water quality

2.12.1.1

An event occurring during pump operation (for example, a pump doesn't work properly), could result in the following:

(a) If there are fluctuations in water pressure resulting in pre-coat filters becoming compromised, or lack of treatment of pool water, resulting in a build-up of microorganisms or lack of disinfection in the water. Any of these examples could cause sickness;

(b) If chemicals or disinfectants are not dosed or monitored properly because a process pump fails, microorganisms that are not killed or removed or chemicals that are incorrectly dosed may cause sickness.

2.12.1.2

The operation of pumps can present risks to the health of supply staff. These are acknowledged, but are not discussed further as such risks are the subject of the HSE Act.

2.12.1.3

For every pump in a supply, records should be kept of the following:

(a) Pump identification number;

(b) Pump type;

(c) Maintenance schedule.

2.12.2 Risk summary

The two events creating the greatest risk with pumps are the failure of the recirculation pumps which will lead to lack of pool water treatment, and the failure of a dosing pump to dose chemicals at the correct rate.

The most important preventive measures are:

(a) To have duplicate pumps for critical operations;

(b) To have devices in place to reduce water hammer and similar damage during pump start-ups and shutdowns;

(c) To have preventive maintenance programmes.

2.12.3 Risk information table

The ongoing consistency of pump operation and maintenance of flow rates is crucial to the disinfection process with a high risk that the pool integrity will be compromised. Recirculation pump failure imparts a high risk of water quality reduction and dosing pump failure will result in a high risk of incorrect dosing levels leading to increased germ population and water balance.

2.12.3.1 Event – Changes in water-flows, or water hammer (pressure surges)

Pump failure will result in water quality reduction. See table 46.

Table 46 – Risk information – Water flow changes or pressure surges

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Recirculation pump failure due to mechanical failure or overload (water hammer can also cause pipe failure)	Preventive maintenance programme in place: – regular inspections – lubrication – seal replacement – leaks repaired – corroded components replaced – annual ammeter tests – daily visual inspection Planned maintenance programme for replacement of components as per manufacturer's recommendations All pumps itemised and maintenance schedule followed Duplicate pumps for critical applications Use duplicate pumps alternately (provides a check that both are functioning and will not need to be overhauled at the same time) Align and secure all pump-linked pipework, valves and fittings according to standard practice Install devices to lessen water hammer should it occur, for example: – surge tanks – air chambers – slow-closing check valves – surge suppressors Flows	System pressure Pump maintenance log Water flow Water quality especially FAC	No water Frequent pump breakdowns Frequent poor water quality in the pool Maintenance log not kept Non-compliance with Part 1	Revise, or put in place a maintenance schedule Review service/ duty periods of duplicate pumps (time in operation: time on standby) Close down the pool until remedied
No water because of pump failure due to power failure, or power unable to operate pumps (for example, water leak in other treatment units resulting power cut-off to pump)	Carry out biennial inspection of power source, connections and electrical equipment Consider a standby generator to cut in automatically when main power fails	Flows System pressures Pump maintenance log Water flow FAC	No water movement Frequent pump breakdowns Frequent poor water quality in the pool Maintenance log not kept Non-compliance with Part 1	Prepare and follow inspection schedule Close down the pool until remedied

2.12.3.2 Event – Incorrect chemical dosing leads to poor water treatment

See table 47 for information on incorrect chemical dosing leading to poor water treatment.

Table 47 – Risk information – Incorrect chemical dosing

Causes	Preventive measures	Checking preventive measures		Corrective action
		What to check	Signs that action is needed	
Process pumps do not add the correct dose of chemical	Schedule preventive maintenance, particularly replacement of elastomeric parts: diaphragms; tubing and so on, as per manufacturer's recommendations Calibrate dosing pumps for expected duty Ensure pumps are fit for the purpose, for example, corrosion resistant Provide duplicate pumps for critical functions Daily check amount of chemical used Use day tanks to reduce risk of overdosing Visually check pumps daily Check stroke and speed settings for manual pumps	Clarity Microbiological levels FAC Chemical usage Chemical type being dosed Coagulation process (if appropriate)	Non-compliance with Part 1 Signs of ineffective coagulation/ filtration Difficulty maintaining FAC No maintenance programme in place	Put maintenance schedule in place Review dosing programme Replace pump(s) with one appropriate for the chemical being dosed and its concentration Obtain standby pump (critical functions)

2.12.4 Contingency plans

If an event happens despite preventive and corrective actions taken, the pool manager may need to be consulted to assess the degree of seriousness.

2.12.4.1 Event – Poor quality assurance, or quality control for monitoring, or both

Poor quality assurance or quality control for monitoring may be detected from the indicators provided in table 48. A list of required actions to cope with this contingency is also provided.

Table 48 – Event indicators and contingency actions – Poor quality control

Indicators	Pool levels difficult to maintain Pump failure Flow significantly reduced Pressure decrease or fluctuations Incorrect water quality chemical or characteristic – see table 1 Increased chlorine demand Widespread illness of pool users linked to the pool water
Required actions	If chemical contamination is suspected, monitor concentrations of the suspected chemical or characteristic and follow the actions provided in Part 1 Identify the reason for pump failure, repair or use standby pump, and plan for long term preventive measures Ensure that chlorine residuals are in accordance with Part 1 of this Standard Review laboratory results and take further samples if necessary Record cause of system failure and steps taken to correct Review the PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.12.4.2 Event – Microorganisms are not killed or removed during treatment because of pump failure

Microorganisms not killed or removed because of pump failure may be detected, and actions taken as shown in table 49.

Table 49 – Event indicators and contingency actions – Pump failure

Indicators	Visual observation of ineffective coagulation, see Appendix B No, or low, chlorine residual leaving the treatment plant Pump failure Elevated levels of turbidity or chemical determinands Increased chlorine demand, which may not be met
Required actions	Follow the actions prescribed in Part 1 Identify the reason for pump failure, repair or use standby pump, and plan for long term preventive measures Ensure that minimum chlorine residuals as required in Part 1 can be maintained in the pool water Review laboratory results and take further samples if necessary Record cause of system failure and steps taken to correct Review the PRMP and modify it if necessary
Responsibility	Manager designated responsible for the quality of pool water

2.12.5 Pool risk management plan performance assessment

Periodic checks are needed to ensure that the pool risk management plan is properly handling the events nominated.

Table 50 provides the detailed information for checking pump performance.

Table 50 – Pump performance assessment

What to measure or observe	Either system pressure or flow rates or both Pump maintenance log books Determinands affected by the performance of treatment processes using process pumps Consumption of treatment chemicals (no or little change may identify pump failure) Indicator bacteria concentrations FAC Pool water levels NOTE – A number of factors may affect these measurements or observations. A good understanding of the operation of the pool water treatment and circulation system will help to interpret the results.
How often	For the monitoring frequency for indicator bacteria measurements, see Part 1 System pressures and maintenance logbooks should be checked at a frequency considered necessary by the manager responsible
What to do with the results	Record results to meet requirements of this Standard or to allow PRMP performance assessment The collected data need to be periodically reviewed to see whether problems with this supply element are developing. This should be done as frequently as the manager responsible considers necessary to minimise risk to public health arising from this pool water quality element Should this review show any unusual incidents, identify that proper procedures are not being carried out, highlight poor laboratory results, or show that poor water quality is reaching customers, then review the procedures for the management and operation of pumps Evaluate the monitoring results, and any actions taken as the result of having to implement a contingency plan, to see if the PRMP needs modification – for example, preventive measures are up to date; the contingency plan steps are still adequate; and changes to the management and operation of pumps are recognised in the plan
Responsibility	Manager designated responsible for the quality of pool water

2.13 Risk management guide – Alternative treatment systems

2.13.1 Introduction

Treatment processes that are different from those detailed elsewhere in this Standard are to be operated efficiently and risk assessed appropriately. This guide is based on the pool water not meeting the requirements of Part 1.

2.13.1.1

Treatment processes may include, but are not limited to, any one or more of the following: alternative filtration (such as membranes), alternative disinfection.

2.13.1.2

When other means of disinfection are used it is not sufficient to show that routine microbiological tests give uniformly satisfactory results. A full risk assessment should be carried out including examination of the following questions when testing a new disinfectant under practical conditions:

(a) How does efficiency and efficacy vary with pH?

(b) Is the contamination in the pool destroyed by the disinfectant and, if not, does it interfere with its action?

(c) Is the efficacy of its action adequately gauged by using microbiological tests (see table 4) as the indicator mechanism?

(d) Is the speed of disinfection comparable with that of chlorine?

NOTE – Particular attention should be paid to this.

(e) Are there any chemical toxicity issues?

(f) Consideration of pool turnover and pool load factors.

2.13.2 Risk summary

Identify the greatest risk involved in the alternative treatment. The most pressing issues are those where microorganisms are not controlled or the water becomes a risk to pool users.

The most important preventive measures are to regularly maintain the treatment processes and ensure they are operated in accordance with the manufacturer's instructions

2.13.3 Risk information table

Each alternative treatment process must have its own risk assessment completed.

It is recommended that existing but similar risk management guides be used for each new alternative treatment process.

APPENDIX A – HEALTH CONSIDERATIONS

(Normative)

A1 Contamination by pool users

Pollution of pool water by pool users through excretion is common. A pool user can lose up to one litre of sweat per hour when actively swimming in water at 24°C at an ambient air temperature of 30°C. Approximately 20 – 35g of urea is excreted in urine every 24 hours, and a normal adult excretes about 25 – 50 mL per pool session. The contribution from this source can be lessened if the bladder is emptied before entering the pool. Perspiration and urine contain mostly water, with dissolved sodium chloride, calcium, magnesium salts and nitrogenous compounds contributing to the total dissolved solids content of the water. Although this may be offensive, it is neither particularly toxic nor unhygienic.

Organic matter introduced into a pool in this way consumes chlorine and adds to the cost of maintaining water purity. In particular, some nitrogenous matter contained in urine (for example urea, creatinine) not only consumes relatively large quantities of chlorine but may produce chlorinous compounds which could be confused with, or interfere with the action of, reaction products of chlorine and ammonia (for example, dichloramine). The smell of chlorinous compounds is likely to be offensive. Every attempt should be made to reduce contamination in pools to a minimum. Toddlers' pools are a particular problem so the turnover rate for pool water (turnover time) should not exceed one hour and these pools should have an independent circulation system.

Urea is broken down slowly by free chlorine residual, so the concentration of urea in a pool with a high pool load factor could be several mg/L.

A2 Transmission of infection by swimming pool water

The risk of contracting disease during pool use in a properly controlled pool is minimal. Where epidemics associated with pools have occurred, investigations have usually revealed clear evidence of unsatisfactory standards of hygiene and water purification, creating conditions conducive to the transmission of infection. Disinfection shall be maintained to ensure effective treatment. Frequent checks shall be carried out to ensure that a high standard of treatment and water quality is achieved (see 1.4 and table 1 to table 4).

A3 Spread of disease

Diseases may be spread at pools by ways other than water as an intermediary. When large numbers of people are present the risk of disease spreading by personal contact or airborne infection is increased. This is a sound reason for avoiding overcrowding of the pool and changing areas and for maintaining pool surrounds and facilities in a hygienic condition.

A4 Faecal accident procedures

Faecal accidents will contaminate pool water. A pool-specific procedure shall be implemented for dealing with faecal accidents. Guidelines on matters to address in a faecal accident procedure are given in A4.1 and A5. All incidents and follow-up actions shall be documented.

A4.1 Faecal solids

The following procedure shall apply:

(a) Evacuate and isolate the pool;

(b) Remove solids and dispose of them safely;

(c) Spot superchlorinate (in excess of 100 mg/L) using a water can or similar in the area where the solids were found. Pool-specific procedure sheets should be used to estimate the amount of chlorine to be applied. See Appendix C3.3;

(d) Keep the pool clear for a minimum of:

  (i) 30 minutes after free chlorine tests indicate a minimum of 5 mg/L FAC has been reached throughout the pool

  (ii) 1 hour in typically large volume or deep pools (for example, diving pools) when the FAC concentration is between the normal operating level and 5 mg/L.

(e) Ensure chlorine is adequately dispersed (below 5 mg/L in all of the pool) before allowing people to re-enter the area. Test the pool water in several locations to check chlorine dilution;

(f) Complete and sign off the incident documentation.

NOTE – If the water in the contaminated pool cannot be isolated from other pools, then this procedure shall be applied to all affected pools.

A5 Diarrhoea

An incident involving diarrhoea may create a higher health risk than an incident involving solid material because diarrhoea is more likely to contain pathogens such as *Giardia* and *Cryptosporidium*. These microorganisms are difficult to remove from water by conventional pool water treatment processes.

A5.1

The pool characteristics in table A1 should be taken into account to assess the risk associated with a diarrhoeal incident. The risk profile for each pool shall be ranked Low, Medium, or High based on the ranking criteria, and the faecal incident management procedure shall be prepared as per A5.2. See A8 for further information.

Table A1 – Risk assessment for diarrhoeal incidents

Risk criteria	Risk assessment		
	Low (meets all but one risk criteria below)	**Medium** (meets two or more risk criteria below)	**High** (meets one or more risk criteria below)
Turnover rate	<1.0 hrs	1.0 hrs – 3.0 hrs	>3.0 hrs
Filtration type	Sand and coagulant dosing optimised(1) Pre-coat filtration optimised(1)	Sand and coagulant dosing not optimised(1) Pre-coat filtration not optimised(1)	Sand only
Recirculation	Separate for each pool	NA	Combined
Swimmer profile	Adults and youths	Mixed age, with preschoolers and primary age children well represented	Preschoolers and primary age children
Disinfection			
(a) Chlorine only	At turnover rate <1.0 hr	At turnover rate 1.0 hrs – 3.0 hrs	At turnover rate >3.0 hrs
(b) Chorine and tertiary oxidation process(2)	At turnover rate <1.0 hr	At turnover rate 1.0 hrs – 3.0 hrs	At turnover rate >3.0 hrs
Water quality	FAC compliant previous 24 hours	FAC non-compliant previous 24 hours	FAC non-compliant previous 24 hours(3)

NOTE –

(1) Optimised means ex-treatment plant turbidity measurements are below 0.1 NTU, 99% of the time based on continuous monitoring or a manual daily sample.

(2) Full stream ozonation, UV systems rated for pool water treatment, and onsite generated chlorine dioxide.

(3) See 2.7.

A5.2

The health risk is potentially even higher when the incident involves a child, occurs when the incidence of cryptosporidiosis is high, or if the pool is located in an area recognised as an endemic notifiable disease area, or at a time when an outbreak of infectious disease is occurring in the local community. If this is the case all pools shall be considered, and managed, as high risk in the event of a faecal incident.

The following procedure shall be used when there is a diarrhoea-related incident but if there is a perceived 'heightened health risk' the following should be implemented:

(a) Evacuate and isolate the pool;

(b) Remove any solids with a scoop and dispose of them safely;

(c) Vacuum the pool to remove solid material, and:

  (i) If the pool is assessed as a low risk, leave the pool closed for one turnover or 1 hour, or

  (ii) If the pool is assessed as a medium or high risk, leave the pool closed for three turnovers.

(d) Increase FAC to no less than 5 mg/L and maintain this level for the shutdown period. Pool specific procedure sheets should be used to estimate the amount of chlorine to be applied. See Appendix C3;

(e) Ensure chlorine is adequately dispersed (below 5 mg/L in all of the pool) before allowing people to re-enter the area. Test the pool water in several locations to check chlorine dilution.

(f) Complete and sign off the incident documentation.

A5.3

The following options may also be useful:

(a) Drain the pool, disinfect the pool, and start again; and

(b) Shock dose with another suitable disinfectant (seek advice).

A6 Vomiting

A vomiting incident may create a high health risk to pool users, depending on the cause. Vomit associated with gastroenteritis may contain a large number of pathogens, whereas vomiting related to other causes, is unlikely to pose a health risk to other pool users.

A6.1

In the event of a vomiting incident the pool management shall immediately attempt to ascertain the cause of the vomiting and take action as follows:

(a) If there is any indication that the person involved has gastro-enteritis or an infectious enteric disease, or they have had recent contact with a person with gastro-enteric disease or diarrhoea or vomiting, then procedure A5 shall be followed;

(b) If the person does not have gastro-enteritis and has had no known recent contact with a person with gastro-enteric disease or diarrhoea or vomiting, and a plausible alternative cause of vomiting can be established, then the procedure A4.1 shall be followed;

(c) If no plausible cause of the vomiting incident can be established, or if no attempt is made to investigate the cause, then the procedure A5 shall be followed.

A7 Notifiable disease outbreaks

A7.1 General

The public health unit will notify swimming pool managers if there is a notifiable disease outbreak in the area, and there is epidemiological evidence linking a pool to an outbreak. Do not conduct additional microbiological tests unless requested by the public health unit, and seek advice on remedial steps to be taken.

Criteria for closing pools due to a notifiable disease outbreak will be in consultation with the public health unit. A pool shall be reopened when testing identifies negative results, or the outbreak is declared over.

A7.2 Corrective disinfection measures

Some disinfectants, when added to a pool under controlled conditions, may be effective against resistant microorganisms such as *Giardia* and *Cryptosporidium*.

The effectiveness of a particular disinfectant on a microorganism is defined in terms of C.t values (concentration in mg/L multiplied by the contact time in minutes). These values are determined under specific conditions. When C.t information is applied to a pool, allowances have to be made for variables such as pH, water temperature, and turbidity because these change the contact time required for a disinfectant to achieve the desired 99.9% (3-log) reduction.

Table A2 provides general guideline information.

Table A2 – Guideline contact times and dose rates to inactivate *Giardia* and *Cryptosporidium*

Disinfectant	% kill	*Giardia* inactivation	*Cryptosporidium* inactivation
Chlorine	99.9	2 mg/L for 31 minutes @ pH 8 and when the water temperature is 25oC	NA
		2 mg/L for 37 minutes @ pH 8.5 and when the water temperature is 25oC	
Ozone	99.9	0.5 mg/L for 1 minute and when the water temperature is 25oC	1 mg/L for 7.4 minutes at 25°C 1 mg/L for 4.7 minutes at 30°C
Chlorine dioxide	99.9	0.3 mg/L for 37 minutes when the water temperature is 25oC	1 mg/L for 226 minutes at 25°C 1 mg/L for 147 minutes at 30°C

NOTE –

(1) For more information on Cryptosporidium inactivation by chlorine refer to Korich, D G. et al. (1990). For all other values refer to the Ministry of Health, *Drinking-water standards for New Zealand 2005* revised (2008) and associated documentation.

(2) All guideline contact times have been determined for water with a turbidity of less than 1.0 NTU.

(3) The time it takes for target disinfectant residual in the pool to be reached will depend on the turnover rate of the pool and other factors, for example, the number of swimmers.

(4) Contact time is measured from the time the target disinfectant residual concentration has been reached.

(5) As a general rule, the guideline contact times should be considered to be minimum values. The contact times should be exceeded by a safety factor that will depend on the circumstances. A suggested safety margin for normal conditions is to increase the contact time by about 50%.

A8 Pool design considerations

A risk analysis of existing pool design features should be carried out and the findings incorporated into a risk management plan for that pool complex. A planned programme of remedial measures should be implemented.

Key design features that should be reviewed include those set out below.

A8.1 Hydraulic design

Each pool at a complex should ideally have a separate circulation and filtration system. If this is not practicable for all pools at a complex, at least the pools designed for children's use should be modified.

The design of new pool complexes should incorporate separate circulation and filtration systems for each pool.

Turnover times for pools primarily used by children should not exceed 2 hours and preferably should have a higher turnover rate (that is, lower turnover time) based on the expected pool load factor.

A8.2 Pre-coat filtration

A well managed pre-coat filtration system has the capacity to remove particles down to about 5 microns in diameter, so under good operating conditions, can effectively remove some *Cryptosporidium* oocysts and *Giardia* cysts. Given that management of filters is not always optimal, approximately three pool turnovers will be required to ensure that pool water has either a low cyst or oocyst (or both) content once swimmers have left the pool.

The practice of drop coating' (that is, recycling used pre-coat previously deliberately dropped to the bottom of the vessel) shall not be practised.

A8.3 Pressure sand filtration

Sand filters can remove particles down to about 20 microns in size, so in plain filtration mode are ineffective for removing protozoan cysts. The addition of a flocculent (coagulant) on line to a sand filter can achieve cyst or oocyst removal efficacy equivalent to pre-coat filtration if operated optimally for four turnovers.

For small pools, manual addition of coagulant after the backwashing cycle is an acceptable practice, but for larger pools continuous addition of flocculent using an automated dosing system is preferred. Turbidity monitoring of the filtered water is an added refinement that can be used to optimise dose rates.

A9 Cleansing facilities

Showers with warm water and soap should be provided and the importance of their use advertised widely by eye-catching notices placed in strategic positions.

Notices for pool users on hygiene should include the following:

(a) Always wash hands after going to the toilet, changing nappies, or handling pets;

(b) Always wash hands before touching food;

(c) Pool users should not enter the water if they have had diarrhoea in the last 2 weeks;

(d) Parents and caregivers should always take children to the toilet before swimming;

(e) Pool users should always shower before swimming;

(f) Babies should wear tight-fitting togs for swimming, not nappies; and

(g) If you think someone has had a faecal accident in the pool, immediately inform a lifeguard or staff member.

APPENDIX B – COAGULATION AND FLOCCULATION

(Informative)

B1 Introduction

When water loses its 'sparkle' it is possible to improve the clarity by adding a chemical coagulant or a combination of coagulant and flocculant.

Optimised sand filtration combined with coagulation and continuous recirculation will remove protozoa such as *Cryptosporidium* and *Giardia* from pool water.

A coagulant is a chemical which reacts or physically interacts with fine particles of solids or turbidity which contribute to the reduction in clarity to clump them so that they can be removed by filtering (the preferred process), or settle to the bottom of the pool, that is, coagulation.

A flocculent is a chemical which is added after a coagulant or instead of a coagulant to assist the process by which solids coalesce and settle, that is, flocculation.

The rate of coagulation and flocculation is dependent on water chemistry.

When the process of coagulation is referred to in the context of pool water treatment it is acceptable practice to use the terms coagulant and flocculent and coagulation and flocculation interchangeably.

Coagulation is not applicable to pools using pre-coat filters, such as diatomaceous earth, because the diatomite will become clogged. Backwashing of media filters must be sufficient to thoroughly remove this chemical floc.

B2 Coagulants and their use

B2.1 Aluminium sulphate

Aluminium sulphate, commonly called 'alum', is widely used to clarify potable water and has been used to clarify pool water when normal treatment (chlorination and filtration) is unable to cope. Typically alum in controlled doses of 10 – 30 mg/L can be used to help clarify pool water.

Alum should only be used by a trained operator because its strength has to be known, as it can have a significant adverse effect on water chemistry, particularly pH, and can give unpredictable results.

The practice of continuously dosing a metered solution of alum into the pre-filter pipeline is used at some larger aquatic centres, with suitable trained operational staff. Turbidity measurement can be used to monitor the effectiveness of coagulant addition.

B2.2 Polyelectrolytes

Polyelectrolytes (also called polys or polymers) are commonly used to assist in removing solids from water. Although polyelectrolytes are formulated to specific guidelines with a generalised known performance, each particular type has specific performance characteristics and it is difficult to compare the performance of one with another. They are safe to handle, are non-toxic when used according to the manufacturer's recommendations, have little effect on water chemistry and are effective when applied at small doses, rates of generally less than about 1 – 2 mg/L.

Typically, addition of small quantities of polyelectrolyte to a mixing zone (such as the inlet to the balance tank or just prior to the filter) will allow fine particles to coalesce and be removed by filtration in one or two turnovers.

Dose calculations for polyelectrolyte need not be precise. The manufacturer's recommendations should be followed but as a guideline, a dose rate of 1 – 2 mg/L based on the turnover rate will generally be effective.

Polyelectrolytes should not be used in systems with pre-coat filtration, as the polyelectrolyte will cause filter blockage.

B2.3 Coagulant effect on filters

Regardless of the coagulant used, coagulated solids will eventually be removed by the sand filter but some may need to be removed from the bottom of the pool by vacuum.

The filter should be backwashed some time after the coagulant has been added. The time between coagulant addition and backwash will depend on coagulant dose rate and the solids content of the water. It is preferable for the coagulant to be added after a filter backwash to maximise the effectiveness of the process.

If the time lapse between the coagulant addition and a backwash being required (say, due to headloss) is less than a few hours, the applied dose rate was too high. There is generally no long-term filter problem if the dose is too high, but shorter than normal filtration runs may be experienced. If this situation continues seek professional advice.

APPENDIX C – CHEMICAL PRINCIPLES FOR CHLORINATED POOLS

(Informative)

C1 Introduction

Pool chemicals should be considered hazardous, and prior to chemical use and storage users should refer to relevant manufacturer's safety data sheets (SDS) and the HSNO Act.

For most pools the water quality criteria in table 1 will give good clarity, user comfort, and sanitary conditions, provided design and operating conditions (for example, filtration capacity, turnover time, pool load factor) are satisfactory.

The selection of satisfactory conditions for some pools, particularly heavily-loaded pools, will need to be based on operating experience. This should include good record-keeping and frequent analysis for all chlorine fractions.

C2 Chlorine-based treatment chemicals

When added to water, all forms of chlorine create hypochlorous acid and hypochlorite ions, which constitute free available chlorine (FAC).

Chlorine is available in several forms:

(a) *Chlorine gas.* When dissolved in water, chlorine gas produces hypochlorous and hydrochloric acids. Acid decreases the pH and alkalinity of water and an alkali has to be added continuously to avoid excessively low pH and alkalinity. (See Appendix H9.6 for the chemistry of pH and alkalinity control.) Alkalinity and pH should be adjusted prior to the addition of chlorine gas;

(b) *Calcium hypochlorite.* Calcium hypochlorite is available in powder, granules, or tablets, all containing the weight equivalent of 55 – 72% of chlorine gas. For use in pools, hypochlorite has to be dissolved in water and only the clear solutions used;

(c) *Sodium hypochlorite solution.* Sodium hypochlorite solution may be purchased under a variety of trade names which often do not show the strength of the solution. These solutions usually contain 3% to 16% available chlorine by weight.

NOTE –

(1) The solutions are free from suspended solids, and do not have clogging agents. The stability of sodium hypochlorite solution is affected by heat, light, pH, and the presence of metals in solution. Efforts should be made to ensure the solutions are as fresh as possible.

(2) Pre-prepared sodium hypochlorite solution, excluding onsite generated solution, is strongly alkaline and the addition of acid solution (such as sodium bisulphate, hydrochloric acid, or carbon dioxide) to the pool may be necessary to control rising pH values. Acid MUST NEVER be added to chlorine solutions.

➤

(d) Chlorinated cyanurates. Sodium dichloroisocyanurate (sodium dichloro-s-triazine-trione) and trichloroisocyanuric acid release hypochlorite and cyanuric acid when dissolved in water. Sodium dichloroisocyanurate is available in an anhydrous form, which releases hypochlorite equivalent to approximately 65% of its weight as chlorine, and a more stable dihydrate form, which releases hypochlorite equivalent to approximately 55% of its weight as chlorine. Trichloroisocyanuric acid releases hypochlorite equivalent to approximately 91% of its weight as chlorine.

(e) Cyanuric acid. In pools, chlorine in water is broken down by sunlight in addition to losses via breakpoint and other reactions with contaminants. When cyanuric acid is added to water the destructive effect of UV sunlight on chlorine residuals is minimised making it easier to maintain adequate chlorine levels at all times;

NOTE –

(1) Adding cyanuric acid to pools at concentrations above 30 – 35 mg/L substantially decreases chlorine breakdown by sunlight. Cyanuric acid is typically added as a 'slug dose' several times a season, but can be added on a continuous basis as part of a chlorinated cyanurate addition. When chlorinated isocyanurates are used continuously, it is important that the cyanuric acid concentration in the water is monitored as directed in Part 1 (see tables 1 and 2), to avoid disinfection efficacy being compromised.

(2) There is little benefit in having a level of cyanuric acid in excess of 60 mg/L.

(f) Electrolytic chlorination. Sodium hypochlorite solutions are generated by electrolysis of brine (sodium chloride) solution. Electrolytic chlorinators can be used in two ways. Both systems introduce a small amount of alkali to the pool water which has to be neutralised periodically with acid solution (for example, sodium bisulphate):

(i) Addition of sodium chloride directly to the pool and direct electrolysis of pool water. Electrode fouling may increase maintenance. Corrosion problems will also occur with metal pool fittings including some stainless steel. Corrosion-resistant fittings will need to be installed

(ii) Electrolysis of a sodium chloride solution to give sodium hypochlorite solution (approximate concentration 0.8 – 1.0%) which is stored and metered into the pool as required. Electrode fouling problems are minimised and corrosion problems associated with high pool chloride levels avoided. The storage of sodium hypochlorite solution allows high chlorine dosage rates for superchlorination or during periods of high pool load factors, using relatively low-capacity electrolysis systems;

(g) Lithium hypochlorite. Lithium hypochlorite is available as a granular, free-flowing, dust-free solid containing the weight equivalent of 35% of chlorine gas. Lithium hypochlorite is readily soluble in water to give clear, sludge-free solutions in soft waters.

C3 Principles of free available chlorination

C3.1 Control of disease organisms and contaminants

Free available chlorination is the practice of adding sufficient chlorine to a pool to ensure the presence of free available chlorine (FAC) at all times. Free available chlorine is a powerful bactericide and algicide and its oxidising properties facilitate the removal of contaminants. The presence of FAC at relatively low concentrations will minimise the possibility of disease transmission between pool users and assist in the maintenance of pleasant pool appearance and swimming conditions.

Chlorine is not particularly effective against protozoa such as *Giardia* and *Cryptosporidium*. For further information, see Appendix A7.

For domestic pools, intermittent dosing of the dissolved chemical (that is, liquid chemical or dissolved solid chemical) over the entire surface of the pool can be used. The pump and filter should be operated during dosing to facilitate mixing. An adequate free available chlorine concentration has to be maintained to provide a reserve to cover inevitable chlorine losses.

The occasional addition of chlorine before water passes through the filter will minimise the development of microbiological growths in filters.

C3.2 Pool user comfort

Careful control of the chlorination process and pool chemistry is necessary to ensure that products formed from the reaction between contaminants (notably ammonia and organic nitrogen compounds) and chlorine do not cause severe eye irritation or excessive chlorinous odours. When ammonia and organic nitrogen (from body fluids) are added to chlorinated water a series of compounds called chloramines is formed. At higher pH values (about 8.0 – 8.5) and low free available chlorine concentrations (below 1 mg/L), monochloramine is the major chloramine formed. At lower pH values and high free available chlorine, dichloramines, and nitrogen trichloride (also called trichloramine) are formed. The operation of the pool at high pH and low chlorine concentration could potentially compromise chlorine disinfection.

Free available chlorine itself causes very little if any eye irritation or chlorinous odour under normal pool operating conditions, but chloramines are increasingly irritant, volatile, and odorous as their chlorine content increases. Even low concentrations of nitrogen trichloride will cause significant eye irritation.

Principal indicators of good pool water quality for comfort and optimum sanitary conditions are high water clarity, low combined chlorine residual, low TDS, free chlorine residual at the recommended concentration, and balanced pH and alkalinity.

C3.3 Superchlorination

Free available chlorine is used up when it destroys microorganisms and organic contaminants (such as algae and waste) in a pool or spa. When excess microorganisms, algae, and organic contaminants are present the pool must be superchlorinated. Superchlorination involves a single heavy chlorine dose to give pool concentrations of 10 – 15 mg/L and allowing an overnight reaction period with the filters running.

It is important when performing a superchlorination that the pool or spa cover is removed from the surface and that the pump and filter(s) are left running for maximum chemical circulation. If the pool or spa is indoors, make sure the room is adequately ventilated.

Superchlorination helps maintain clean filters, destroys resistant microorganisms which may accumulate in the filters, and partially oxidises accumulated organic matter.

Superchlorination at a concentration of about ten times the combined available chlorine level (CAC) should be carried out weekly or when any of the following occur:

(a) Loss of clarity or change of water colour;

(b) No FAC reading;

(c) After extreme heavy pool loading;

(d) Presence of a chlorinous or unpleasant odour;

(e) Non-conforming bacteria count;

(f) CAC exceeds 1.5 mg/L.

An overnight reaction period should be allowed after superchlorination, and the free chlorine residual should be checked before the pool is used again.

APPENDIX D – ALTERNATIVES TO CHLORINE FOR POOL DISINFECTION

(Informative)

D1 General

Effective operation of a pool relies on a combination of correct operation of an optimised filter system and the correct application of a disinfectant.

Chlorine and chlorine-based products form the basis of the most commonly used disinfection processes, but under some circumstances alternative disinfection processes may offer specific advantages.

D2 Bromine

Bromine, like chlorine, is a chemical element of the halogen family and is an important, though poorer, pool disinfection agent. It is also a poorer oxidising agent. Bromine compounds used for pools are manufactured in a granular, liquid, and compressed tablet, or stick form.

The hypobromous acid formed when bromine is added to water reacts with ammonia and nitrogenous body wastes to form bromamines. Bromamines do not have the irritating odours and do not cause eye irritations commonly associated with combined chlorine disinfection systems.

Bromine is acidic and therefore pH and alkalinity adjustments will be required.

Pool disinfection systems based on bromine include:

(a) BCDMH (Bromo-chloro-dimethylhydantoin) in its compressed form has all the active ingredients necessary in one application to form the required hypobromous acid. This product can be applied by a bromine feeder;

(b) The sodium bromide method of disinfection is a two-part system, is an alkali salt with no disinfecting properties, and is usually available as a concentrated liquid of approximately 30% active strength (by weight). Sodium bromide solution is applied to water in order to establish the inert bromide ion bank.

The inert bromide ion is activated by the addition of an oxidising agent, typically chlorine. The activation reaction produces hypobromous acid, the active disinfectant. Bromine has only half the disinfectant power of chlorine and therefore twice as much must be added to the pool to achieve similar disinfection rates.

D3 Ozonation

D3.1 Ozone production

Ozone is a gas which is a more powerful oxidant and more effective bactericide than chlorine and must be used in conjunction with a residual type disinfectant (for example, chlorine or bromine). The ozone residual must not be allowed to enter the pool.

Ozone gas is produced on site by passing dry air or oxygen through a series of electrodes. A moderate voltage is applied to the electrodes and a small amount of the oxygen in the air is converted to ozone. This process is known as corona discharge.

Ozone can also be produced in very small quantities from ultraviolet (UV) light treatment systems, but the process is inefficient and not recommended for pool water treatment.

Ozone disinfection and oxidation systems are sized to meet the particular characteristics of the pool complex. Installations normally require automatic control of pH, chlorine residual and ozone residual in addition to normal monitoring requirements outlined in 1.4 of Part 1. This is because of the difficulty involved in measuring ozone residuals manually.

D3.2 Ozone activity

The role of ozone treatment is primarily the destruction of harmful microorganisms and oxidation of dissolved and colloidal organics which have not been removed by the filter. Because of the toxicity of ozone it must be removed before water is returned to the pool and this is typically achieved by activated carbon which also adsorbs organics. Clean ozone-free disinfected return water, with no dissolved organic matter to exhibit chlorine demand, is dosed with a holding disinfectant (usually chlorine based) to maintain sanitary conditions. The usual treatment sequence is:

(a) Primary filtration;

(b) Ozone generation, mixing;

(c) Reaction chamber detention;

(d) Activated carbon filtration;

(e) Holding disinfectant dosing.

D3.3 Ozone effectiveness

Ozone can break down urea and other nitrogen containing organics that are found in pool water. Ozone also has a high disinfection efficacy against all microbiological groups including protozoans and viruses.

In some circumstances ozonation is effective against the protozoa *Giardia* and *Cryptosporidium* at suitable concentrations and contact times. For further information, see Appendix A7.2.

D4 Polyhexamethylene biguanide hydrochloride/didecyl dimethyl ammonium chloride/hydrogen peroxide

Polyhexamethylene biguanide hydrochloride (PHMB)/didecyl dimethyl ammonium chloride (DDAC)/hydrogen peroxide are used principally for domestic pools and lightly-loaded public pools. PHMB/DDAC/hydrogen peroxide are not recommended for treatment of heavily used or public pools.

These chemicals form a three-part system. The PHMB sanitiser should be used in combination with the DDAC algicide and the hydrogen peroxide oxidiser.

This system is not recommended for use in spa or swimming pools fitted with an aeration device because there may be excess foaming. More frequent filter backwashing may be necessary because flocculent action puts more reliance on the filters than other disinfectants.

Chlorine and bromine-based chemicals, products containing anionic detergents, and products containing copper compounds are incompatible with this system.

The PHMB disinfectant level should be maintained in the range of 25 – 50 mg/L and the pH level within the range of 7.2 – 7.8. DDAC algicide is added weekly at the rate of 1 mg/L. Hydrogen peroxide oxidiser is added monthly at a rate of 100 mg/L.

Normal water balance parameters (that is, 80 – 120 mg/L total alkalinity) should be maintained and calcium hardness adjusted to achieve the required saturation index. See Appendix H9.2.

D5 Ionic treatment (copper-silver ion treatment)

An ionic treatment system discharges an electric current through electrodes to produce copper and silver ions. Possible toxicity effects from overdosing the ions, corrosion, and inability to easily measure disinfection ability preclude using this type of system other than as a supplementary treatment with regular chlorine dosing on lightly-loaded domestic pools.

D6 Ultraviolet treatment

Ultraviolet treatment alone should not be used for disinfection because no disinfectant remains in the water after irradiation. Therefore this treatment needs to be used in conjunction with a residual sanitiser.

Some ultraviolet treatment systems have the ability to break down chloramines.

Ultraviolet treatment systems designed for swimming pool treatment are effective at breaking down chloramines previously formed by the reaction of chlorine with organic material, and under low turbidity conditions are effective at destroying protozoa such as *Cryptosporidium* and *Giardia*.

D7 Chlorine dioxide

Chlorine dioxide is a more effective disinfectant and oxidising agent than chlorine and is normally generated on site as an aqueous solution. The solution is unstable and difficult to handle so its use in pools has been limited.

Stabilised liquid forms of chlorine dioxide are available but the efficacy of each is not easy to quantify. More recently it has become available in the form of pellets of a chemical which releases free ClO2 on contact with water. It cannot be assumed the efficacy of these forms of chlorine dioxide are equivalent to those generated on site.

Chlorine dioxide is typically used in low concentrations (0.2 – 0.5 mg/L) to avoid the formation of excessive concentrations of the undesirable product chlorite.

Chlorine dioxide does not react with ammonia but does react with other organics in the pool so has a 'demand' analogous to chlorine. Efficacy is also relatively unaffected by the pH range normally found in pool water.

In some circumstances chlorine dioxide is effective against the protozoa *Giardia* and *Cryptosporidium* at suitable concentrations and contact times. For further information, see Appendix A7.2.

D8 Other means of disinfection

When other means of disinfection are used it is not sufficient to show that routine microbiological tests give uniformly satisfactory results. A full risk assessment should be carried out.

APPENDIX E – CHEMICAL DOSING PROCEDURES

(Informative)

E1 Chlorine dosing

It is important that everyone handling chemicals takes appropriate safety precautions including wearing safety clothing, goggles, and a respirator if necessary. See Appendix F of this Standard and refer to NZS 4441 for safety requirements and procedures.

E1.1 Adjustment of chlorine dosage rates

The rate at which chlorine is added to water in order to maintain the desirable free available chlorine levels will be affected by many factors, including pool use, temperature, sunlight, and presence of adequate cyanuric acid levels.

Pool use is often the predominant factor determining the required rate of chlorine addition, but experience based on careful recording of the various determining factors provides the most reliable basis for selecting a schedule of dosing rates.

The daily chlorine dosing pattern needs to anticipate chlorine consumption, to ensure the presence of adequate, but not excessive, free available chlorine at all times. For example, for a day when a heavy pool use is expected the chlorinator may be set to deliver chlorine at a rate of 2 mg/L per hour for the 5 hours during the heaviest pool use (plus 1 hour before), and 0.25 mg/L for the remainder of the 24 hours, giving a total daily dosage of 16.5 mg/L.

When a pool starts operating, it is preferable to use relatively high dosage rates for the expected pool use/bathing load factors, and reduce these rates in the light of experience, guided by regular free available chlorine tests. It may be necessary to turn the chlorinator off periodically if very low dosing rates cannot be achieved.

E1.2 Calcium hypochlorite solutions

Dissolve calcium hypochlorite in powder or granule form and add it to the pool as a settled, clear solution.

When calcium hypochlorite is dissolved, some insoluble calcium-rich 'lime' sludge remains. This sludge must not enter the feed-line to the chemical dosing pump. See Appendix H7 for information on excess calcium testing. A filter or float device on the suction line will ensure that the settled sludge is not withdrawn. When 10 – 20 mm of insoluble sludge has accumulated in the solution tank, draw off about a half to three-quarters and dispose of it safely. Consult the appropriate local authorities.

Make up sufficient solution for 25 – 26 hours of continuous dosing. Solution strength should not exceed 3% of calcium hypochlorite (at 2% chlorine), and lower concentrations may reduce clogging, depending on the range of chemical dosing pump pumping rates, and chlorine dosage rates required.

E1.3 Sodium hypochlorite solutions

Where necessary make up sufficient solution for 25 – 26 hours continuous dosing.

For pools changing from dosing calcium hypochlorite solution to sodium hypochlorite, dilute the concentrated sodium hypochlorite solutions to approximately 2 – 5% to ensure that the required dose rate is within the optimum operating range of the dosing pump. Where pools are designed for direct dosing of concentrated sodium hypochlorite (a 13% FAC), no solution preparation is necessary.

Use a purpose-made siphoning apparatus (plastic) or a small transfer pump to transfer the solution from storage containers to the dosing tank.

The dosing tank should be marked permanently to show the volumes corresponding to the depth of solution in the tank.

Where the water supply is 'hard', the pH of the sodium hypochlorite solution may precipitate calcium carbonate. Solutions made up from hard water will require settling, the same as for sludges from calcium hypochlorite solutions. A two-tank system and filter/float device on the suction line should be used.

E1.4 Sodium dichloroisocyanurate

Sodium dichloroisocyanurate is typically used in spas and domestic/smaller pools and can be hand dosed directly to the pool. Sodium dichloroisocyanurate can also be used as a supplementary 'hand dose' to boost the existing chlorine residual in a pool. Sodium dichloroisocyanurate is also known as sodium dichloro-5-triazinetrione dihydrate.

E1.5 Trichloroisocyanuric acid

Trichloroisocyanuric acid tablets may be used in a floating dispenser or appropriate erosion feeder. Handle tablets with care.

E2 Cyanuric acid

E2.1 General

Cyanuric acid dissolves only slowly and to a limited extent in water and therefore unlike other pool chemicals, cannot be added to pools as a highly concentrated solution. (Cyanuric acid is also known as 1,3,5-triazine-2,4-6(1H,3H,5H)-trione.) Test the pool water in accordance with Appendix H.

If the pool contains little or no cyanuric acid, add an initial dose to give a concentration of 30 – 50 mg/L using one of the following procedures:

(a) Pools with balance tanks. In many pools, the most convenient procedure will be to sprinkle cyanuric acid into the balance tank. Flow through the tank will usually ensure that any cyanuric acid dissolves within 48 hours, but sometimes it may be necessary to stir up any cyanuric acid deposits which persist in the tank. Any solid cyanuric acid which is carried out of the balance tank in the flow to the filter will be retained in the filter and dissolve from there. If possible avoid backwashing the filter for a day or two after adding cyanuric acid to allow maximum time for dissolution. It is unnecessary to stop pool use if this procedure for adding cyanuric acid is used;

(b) Pools without balance tanks. Sprinkle the required amount of cyanuric acid over the pool. For pools with a 'vacuum to filter' option, leave the cyanuric acid for 24 hours, then vacuum the pool on to a clean filter and do not backwash for 2 – 3 days. Where there is no 'vacuum to filter' option, leave the cyanuric acid for 48 hours before vacuuming the pool to waste. The pool should not be used until the vacuuming has been completed. Creating some mixing in the pool such as towing a bucket may speed dissolution of cyanuric acid. For make up under normal water loss (splash out) conditions, add approximately 15 mg/L cyanuric acid every 2 months. If high chlorine dosages are required to maintain adequate FAC during periods of very light pool load, especially in bright sun, add a booster dose of 15 mg/L cyanuric acid.

E2.2 Use of chlorinated cyanurates

Cyanuric acid may also be added to pools indirectly by using chlorinated cyanurates as a chlorine source. It is still necessary to add cyanuric acid directly until the desired range (30 – 50 mg/L) is achieved. At this stage the level can be maintained with either the use of chlorinated cyanurates or the use of cyanuric acid with another chlorine source not containing the cyanurate. When chlorinated isocyanurates are used continuously, it is important that the cyanuric acid concentration in the water is monitored as set out in Part 1 (see tables 1 and 2), to avoid disinfection efficacy being compromised.

APPENDIX F – SAFE HANDLING, STORAGE, AND MANAGEMENT OF CHEMICALS

(Informative)

Pool chemicals should be considered hazardous, and prior to chemical use and storage, users should refer to relevant safety data sheets (SDS) and the HSNO Act.

Failure to follow correct chemical handling procedures could result in serious injury or death. Occupational Safety and Health (OSH) requirements and manufacturer's chemical handling and storage requirements should be followed. Safety data sheets are available for all chemicals and should be obtained from the supplier or manufacturer of the product.

Take specific note of chlorine compounds and all the safety precautions that are required when dealing with these chemicals. For chlorine gas installations, refer to AS/NZS 2927.

Instructions on emergency procedures and on safe storage and handling procedures should be prominently displayed in the area where chemicals are handled and mixed. Follow the manufacturer's or supplier's instructions when disposing of chemicals.

For more guidance refer to http://www.osh.dol.govt.nz and http://www.erma.govt.nz.

APPENDIX G – CHECKLIST OF DUTIES AND PROCEDURES FOR SAFE OPERATION OF SWIMMING POOLS

(Informative)

G1 Records

Full written records of pool water management are recommended. The minimum requirements are set out in Appendix H.

G2 Operating manuals

From the following model, develop a checklist and formalise specific pool operating procedures in the form of an operating procedures manual. The operating manuals developed should include:

(a) Operating procedures;

(b) Equipment details including maintenance log;

(c) Chemical inventory; and

(d) Staff responsibilities.

Preparation and operation of a risk management plan in accordance with Part 2 will help to ensure the pool is operated correctly.

G3 Checklist

G3.1 Daily duties

The following procedures should be carried out daily:

(a) Remove or replace pool cover;

(b) Make up daily chlorine solution according to the procedure in Appendix E, and allow it to settle (as appropriate);

(c) Record the amount of disinfectant (for example, calcium hypochlorite or sodium hypochlorite) used;

(d) Check that the solution is flowing freely in the chlorinator lines and that the dosing pump is working efficiently. Clean out the lines and remove air locks if necessary;

(e) Use table 2 for swimming pools or table 3 for spa pools (see 1.4.3) to determine minimum chlorine test frequencies and to determine the need for microbiological testing (see 1.4.4.1.1 and 1.4.4.1.2);

(f) See table 1 (in 1.4.3) for recommended water quality criteria;

(g) Adjust the chlorine feed rate depending on chlorine test results, experience, and expected pool load factor. Record all changes and times of adjustments;

(h) Adjust pH and alkalinity as necessary;

(i) If water clarity, smell, or other factors identify the need, take the appropriate action – for example, superchlorinate (see C3.3);

(j) Clean out the hair and lint strainer. Stop pump first and operate valves;

(k) Clean debris from the skimmers. Check that skimmers are drawing-off the surface water. If not, top up the pool;

(l) Check for and remove debris in the pool (glass, large objects) or on the pool surface (leaves, clippings). Rectify any vandalism if necessary;

(m) Hose down the entire concourse, sheds, and toilets with a high pressure hose. Wash chemical spills immediately;

(n) Check the water level. Top up if necessary and record the amount added (if water meter provided);

(o) Check for loss of suction and re-prime pump whenever necessary especially after altering valve positions, cleaning strainers;

(p) Check and record the filter pressures/headloss gauge. Backwash if necessary;

(q) Check pool load factor and record it;

(r) Record weather conditions (outdoor pools);

(s) Check for any unusual sounds in the filter house;

(t) Check the filter motor temperature (is it hotter than usual?);

(u) Check for leaks;

(v) Clean the filter house and check the security of the filter house and chemical store.

G3.2 Twice-weekly duties

The following procedures should be carried out twice a week:

(a) Inspect records of the quantities of chlorine used daily, and if these show an increase that is not explained by any one or more of the following: changes in weather, pool use/loading, or if a test for cyanuric acid shows, add the equivalent of 20 mg/L of cyanuric acid (see G6.4, and Appendix C2).

(b) Check the need to vacuum clean the pool and clean if necessary (see G5);

(c) Check and record the filter back-pressure/headloss gauge and backwash if necessary;

(d) Scrub clean changing areas, showers, toilets, handbasins, and so on with chlorine solution (at 2.5 g/L – 25 g or 2 tablespoons in 10 litres). Ventilation is necessary to remove toxic chlorine fumes.

G3.3 Fortnightly duties

The following procedures should be carried out every fortnight:

(a) Check stocks of treatment chemicals and test chemicals. Replace as required;

(b) Check the test equipment and safety equipment;

(c) Dispose of sediment from the chlorine solution tank, as applicable.

G4 Operating procedures

G4.1 Filter plant and pool details

In each filter shed display a prominent wall notice or record filter details in the operating handbook. A sample format for a notice or record book is given in table G1.

Table G1 – Sample notice for filter plant and pool details

Make, type, and model of filter plant	
When to backwash?	
Agent's name	
Agent's telephone number	
Make, type, and model of pump	
Agent's name	
Agent's telephone number	
Contacts for emergencies:	1 .... 2 ....
Pool surface area (length x width)	.... m^2
Pool volume (surface area x average depth)	.... m^3
Pool built before 2008: Design pool load factor (pool volume divided by total number of pool users per day)	.... Litres/person/day
Pool built to NZS 4441:2008: Instantaneous bathing load - for pool < 1 m deep = surface area ÷ 2.2 - for pool 1 – 1.5 m = surface area ÷ 2.7 (for pools <35°C bather numbers not be >70% of calculated)	
Maximum allowable number of users per day	
Circulation rate	.........................m^3/hr

(Copyright of this form has been waived by Standards New Zealand)

G4.2 Backwashing

For each filter system display a wall notice detailing the procedure for backwashing the filters. Note that:

(a) All valves and pipes should be clearly labelled and identified on the wall notice;

(b) Arrows should be marked on pipes to show direction of flow.

G5 Suction/vacuum cleaning

Suction/vacuum cleaning, to remove debris from the floor of the pool, will be necessary about once a week for outdoor pools, potentially less frequent for indoor pools. It should be done first thing in the morning, allowing dirt to settle overnight. Suction/vacuum cleaning should not be done when users are in the pool.

Where debris is moderate, suction/vacuum clean in the ‘filter to pool’ mode, trapping debris on the top of the filters. Backwashing should follow immediately. Where debris is heavy, suction/vacuum cleaning should be directly to waste (or drain), where it is possible, to prevent filter clogging.

NOTE – Check that the pool water level does not fall below the level of the weirs or skimmers.

WARNING — NEVER BACKWASH WHILE SUCTION/VACUUM CLEANING, because this will block and damage the drain holes from the filter and deposit dirt into the bottom of the sand bed. This dirt will then be sent back into the pool when normal filtration resumes.

Record in the operating manual a specific suction/vacuum cleaning protocol for cleaning the pool. Include the following:

(a) Frequency;

(b) Procedure; and

(c) Safety precautions to be followed.

G6 Application of chlorine and cyanuric acid

See Appendix C for technical details and Appendix E for dosing procedures.

Chorine tests need to be carried out before adjustments are made and a time of about 2 – 4 hours should elapse before the pool is retested.

If test results identify that adjustment is required the following calculations may be used for guidance.

G6.1 Calcium hypochlorite

For manual dosing (domestic pools only):

(a) Decide on concentration required, for example, 5 mg/L (= 5 g/m^3);

(b) Measure pool volume (length x width x average depth),
for example, 15 m x 5 m x 1 m = 75 m^3;

(c) Multiply concentration of chemical required by pool volume,
for example, 5 g/m^3 x 75 m^3 = 375 g;

(d) Adjust, because calcium hypochlorite is normally only 65% effective, so the weight to be added is 375 g x $\frac{100}{65}$; = 577 g;

(e) Rounding up, add approximately 580 g to the pool.

G6.2 Calcium hypochlorite solution

For continuous dosing (all pools) using 3% dosing solution (30 g powder/L = 30,000 mg/L) which equates to 1.95% chlorine. The maximum solubility is only 3%.

(a) Decide on chlorine concentration required, for example, 5 mg/L;

(b) Establish the recirculation flow rate, say 15,000 L/hr;

Then dose = recirculation flow (L/hr) x concentration (mg/L) ÷ solution (mg/L) x $\frac{100}{65}$;

= 15,000 L/hr x 5 mg/L ÷ 30,000 mg/L x $\frac{100}{65}$;
= 75,000 ÷ 30,000 L/hr x $\frac{100}{65}$;
= 3.8 L/hr.

G6.3 Calcium hypochlorite

For manual dosing using 3% (30 g powder/L solution) which equates to 1.95% chlorine. The maximum solubility is only 3%.

(a) Decide on chlorine concentration required in pool, say 5 mg/L; (= 5 g/m^3);

(b) Calculate pool volume (length x width x average depth),
say 15 m x 5 m x 1 m = 75 m^3;

(c) Then chemical weight required in pool = 5 g/m^3 x 75 m^3 x $\frac{100}{65}$ = 577 g;

(d) Make allowance for low (3% or 30 g/L) solution strength of 30 g/L;
Dose = weight required in pool ÷ solution strength = 577 g ÷ 30 g/L = 19.2 L;

(e) Therefore add approximately 12.5 L of solution.

G6.4 Cyanuric acid

For dosing with cyanuric acid:

(a) Decide on concentration required to boost pool water, say 30 mg/L (= 30 g/m^3) of cyanuric acid;

(b) Calculate the pool volume
= length x width x average depth, say 15 m x 5 m x 1 m = 75 m^3;

(c) Weight of chemical to be added
= concentration of chemical required (g/m^3) x pool volume (m^3);
= 30 g/m^3 x 75 m^3;
= 2250 g, or 2.3 kg approximately.

G6.5 Sodium hypochlorite

G6.5.1

For manual dosing:

(a) Decide on concentration required, say 3 mg/L (= 3 g/m^3);

(b) Calculate pool volume
= length x width x average depth, say 15 m x 5 m x 1 m = 75 m^3;

(c) Weight of chemical required in pool = concentration 3 g/m^3 x pool volume 75 m^3 = 225 g;

(d) Adjust because the sodium hypochlorite solution strength is usually between 3% – 15% by weight (shown on the label);

Assume 13% effective, then, solution required to be added = 225 g x $\frac{100}{13}$ =1730 g;

(e) Therefore weight to be added is 1730 g. Because the solution is diluted, 1 mL weighs approximately 1 g, therefore add 1.73 L to the pool.

G6.5.2

For manual dosing for faecal (diarrhoeal) incident management the objective is to increase the FAC to at least 5 mg/L.

As an example, a pool is 25 m x 10 m x 1 m and the measured FAC is 2.5 mg/L (= 2.5 g/m^3)

(a) The concentration required is 5 mg/L. Measure the FAC concentration in the pool – in this example it is 2.5 mg/L so the required dose rate is 5 mg/L – 2.5 mg/L = 2.5 mg/L or 2.5 g/m^3;

(b) Calculate pool volume = length x width x average depth, so 25 m x 10 m x 1 m = 250 m^3;

(c) Weight of chemical required in pool = concentration 2.5 g/m^3 x pool volume 250 m^3 = 625 g;

(d) Adjust because the sodium hypochlorite solution strength is usually between 3% – 15% by weight (shown on the label);

Assume 13% effective, then, solution required to be added = 625 g x $\frac{100}{13}$ = 4807 g;

(e) Therefore weight to be added is 4807 g. Because the solution is diluted, 1 mL weighs approximately 1 g, therefore add 4.8 L rounded to 5 L to the pool.

G6.5.3

For manual dosing for faecal (solid) incident management:

As an example, a pool is 25 m x 10 m x 1 m and the measured FAC is 2.5 mg/L (= 2.5 g/m^3)

(a) The required concentration of FAC in the affected area is 100 mg/L (= 100 g/m^3). Ignore the existing FAC residual;

(b) Calculate pool volume = affected length x affected width x average depth. Under normal circumstances use 5 m x 5 m x average depth, which in this case is 5 m x 5 m x 1 m = 25 m^3;

(c) Weight of chemical required in pool = concentration 100 g/m3 x pool volume 25 m^3 = 2500 g;

(d) Adjust because the sodium hypochlorite solution strength is usually between 3% – 15% by weight (shown on the label);

Assume 13% effective, then, solution required to be added = 2500 g x $\frac{100}{13}$ = 19231 g;

(e) Therefore weight to be added is 19231 g. Because the solution is diluted, 1 mL weighs approximately 1 g, therefore add 19.3 L rounded to 19.5 L to the affected area.

G6.6 Sodium hypochlorite solution

For continuous dosing (all pools) using 13% solution;

(a) Decide on concentration required, say 3 mg/L;

(b) Establish the recirculation flow rate, say 15,000 L/hr;

(c) Dose $= \frac{\text{Recirculation flow (L/hr) x Concentration}}{\text{Solution (mg/L)}}$ (= % solution x 10 x 1,000);

= 15,000 L/hr x 3 mg/L ÷ 130,000 mg/L;

= 45,000 ÷ 130,000 L/hr;

= 0.35 L/hr.

Gas chlorination dosed continuously may also be used to increase the FAC concentration in the pool to 5mg/L.

Solid calcium hypochlorite may also be used as an alternative. See Appendix G6.1 and G6.2.

G7 pH/alkalinity correction

G7.1 Procedure

See Appendix H9 for technical details and Appendix H9.6 for chemical selection.

As a general 'rule of thumb' the following procedure should be adopted when adding acid or alkaline chemicals to a pool:

From Appendix H9.6 estimate the approximate amount of chemical required and add approximately 0.5 kg portions of acid or alkali to a plastic bucket which is already three-quarters filled with water. Stir until the chemical is completely dissolved and tip slowly into a skimmer with the filter system running to ensure rapid mixing.

G7.2 Chemical test procedures

See Appendix H for details.

G7.3 Problem solving

See Appendix J for details.

G8 Winter shutdown

During winter, maintenance should be carried out.

G8.1 Filters

Undertake the following maintenance:

(a) Check sand level is only 150 – 200 mm down from the top rim edge and the sand bed is flat. If this is not the case seek professional advice;

(b) Chemically clean the sand by lowering the water level to the top of the sand. A general clean involves adding 10 – 20 L of settled chlorine solution, soak for 12 – 24 hours and backwash. If the general clean does not improve the sand quality, seek professional advice;

(c) Leave the filter full of water over winter.

G8.2 Dosing equipment

Undertake the following maintenance:

(a) Oil and grease as appropriate;

(b) Replace tubing and O-rings;

(c) Check all valves and repair leaks.

G8.3 Pool structure

Undertake the following maintenance:

(a) Check for, and repair leaks;

(b) Paint surfaces, or repair tiles;

(c) Repair fittings;

(d) Those pools with operational hydrostatic valves in the floor may be left empty over winter;

(e) Pools without operational or possibly faulty valves should be left full over winter to prevent the pool structure being lifted by groundwater;

(f) Under severe winter conditions, extra precautions such as draining pipework should be taken.

G8.4 Chemical winterising

Chlorine is commonly used to maintain an algae-free pool during winter. The procedure is as follows:

(a) Add cyanuric acid to a concentration of 30 mg/L;

(b) Raise free chlorine residual to 2.0 mg/L. Run the plant for 1 – 2 hours to distribute chlorinated water throughout the system;

(c) Close down;

(d) Once weekly, raise free chlorine residual to 2.0 mg/L and operate filtration plant for 8 hours if practical;

(e) Check cyanuric acid level once a month and restore to 30 g/L when necessary;

(f) Check the pool once weekly for signs of algal growth. If algae are present, 'shock' dose with chlorine to 15 mg/L (see superchlorination procedure in Appendix C3.3).

Other methods using algicides are discussed in Appendix J2.3. For procedures for wintering over pools treated with polyhexamethylene biguanide hydrochloride (PHMB) and hydrogen peroxide (see Appendix D4) and refer to the safety data sheet (SDS) for treatment.

G9 Pool start up

One or more of the following procedures should be used for pool start up:

G9.1 After refilling the pool with town water supply:

(a) Turn on the recirculation pump and backwash the filter (see G4.2);

(b) Add cyanuric acid (see G6.4);

(c) Adjust pH and alkalinity (see Appendix H9.6);

(d) Establish continuous chlorine dosing (see Appendix C and G6).

G9.2

Before refilling the pool with other than town water supply seek advice if water quality is 'suspect'.

G9.3 If a winterised pool is to be re-established:

(a) Either shock dose with chlorine, or coagulate, or both (see Appendix B);

(b) Turn on the recirculation pump and backwash the filter;

(c) Add cyanuric acid to appropriate level (see Appendix E2 and G6.4;

(d) Adjust pH and alkalinity (see Appendix H9.6);

(e) Establish continuous chlorine dosing;

(f) Undertake bacteriological testing (see 1.4).

APPENDIX H – WATER QUALITY TEST PROCEDURES, TEST KITS, AND EQUIPMENT

(Informative)

H1 General

It is recommended that expert advice be obtained in selection of kits and equipment. Many test kits are simplified versions of internationally recognised analytical methods. For full particulars of any method refer to the current APHA publication *Standard methods for the examination of water and wastewater*, or equivalent.

Do not place fingers over the open ends of test tubes when dissolving reagents or mixing samples. Do not dispose of test solutions into the pool.

All samples shall be taken so as to be representative of the pool water quality. Record the following information for samples:

(a) Water quality data (see 1.4):
    (i) Date and time sampled
    (ii) Sampling location and depth (see H11 and H12 for details)
    (iii) Name of person who undertook the sampling
    (iv) Storage and transport of sample (if appropriate)
    (v) Name of person or company who conducted the analysis
    (vi) Results (for an example of a result sheet see figure H3)
    (vii) Special conditions at or preceding sampling (such as faecal accidents, very high or low pool load factor, special chemical treatment applied, pool just filled or recharged, operating problems);
(b) Diary of daily activities;
(c) Safety checklists and procedures including accident recording to OSH requirements;
(d) Faecal accident procedures and reporting system (see Appendix A).

H2 Test for chlorine residuals

H2.1 General

Chlorine residual tests most commonly use a colour comparator or photometer and either dry reagents in foil-wrapped tablet or powder form, or liquid reagents or test strip. Only the diethyl-p-phenylene diamine (DPD) test procedure which gives pink colours with desirable chlorine levels should be used. Test methods other than these must compare favourably with DPD test methods described in the current edition of the APHA publication *Standard methods for the examination of water and wastewater*, or equivalent.

Titration procedures, such as the ferrous DPD method or suitably calibrated photometric methods, are not described here but should be the standard procedure used at a large public pool because they give more precise results. Only powder or liquid reagents, not tablets, should be used for the ferrous titration DPD method. Operators wishing to use such techniques should seek expert assistance if they are not thoroughly familiar with the methods.

Colour comparator methods using personal opinion are limited by an individual's ability to differentiate colour. Colour test strips or 'dipsticks' are most vulnerable to contamination and therefore are the most inaccurate methods.

DPD indictor reagents do not last indefinitely and should be replaced according to the manufacturer's directions.

Liquid DPD reagent should be clear and colourless to ensure satisfactory results. Discard and replace any liquid DPD reagent showing any signs of discolouration. The reagent should be stored in a dark bottle, in a cool dark place free of chlorine vapour.

Further information on chemical dosing and chemical principles is provided in section 1.3 and Appendix E.

H2.2 Colour comparison test procedures

Colour comparison methods typically use foil-wrapped tablet reagents, foil-wrapped powder reagents or liquid reagents.

H2.2.1 Free available chlorine (FAC) test

Proceed as follows:

(a) Rinse two test tubes thoroughly in pool water;

(b) Either crush a DPD No. 1 tablet (or use equivalent foil-wrapped powder) into one of the tubes and allow to dissolve in the small amount of water remaining or add the required amounts of buffer reagent and DPD reagent (liquid reagents) and mix;

(c) Collect sample, normally near the skimmer or scum channel, by immersing the second tube, open end down, to elbow depth and then turning upright to fill;

(d) Pour sample into the test tube containing the reagents, filling it to the fill line on the test tube;

(e) Place a plastic cap on the test tube and mix by inverting several times; do not use bare skin (finger or hand) over the open end of the test tube;

(f) Immediately compare with colour standards on the comparator;

(g) Note and record the reading as mg/L free available chlorine (FAC).

H2.2.2 Total available chlorine (TAC) test

Proceed as follows:

(a) Either:

  (i) Add a DPD No. 4 tablet (or use equivalent foil-wrapped powder) into a fresh sample of pool water in a clean test tube, or

  (ii) Crush a DPD No. 3 tablet (or use equivalent foil-wrapped powder) into, or add the required amount of potassium iodide powder or solution to the sample previously read for FAC.

(b) Mix until dissolved and wait 2 minutes;

(c) Compare with colour standards on the comparator;

(d) Note and record the reading as mg/L total available chlorine (TAC).

H2.2.3 Combined available chlorine (CAC) calculation

The combined available chlorine residual concentration is obtained by subtracting the reading for free available chlorine (FAC) from the reading for total available chlorine (TAC). That is: CAC = TAC – FAC.

H2.2.4 For FAC or TAC levels exceeding 4 mg/L

H2.2.4.1

The DPD test procedure is generally considered reliable only up to 4 mg/L. If the concentration in any sample appears to exceed 4 mg/L, even by a small margin, a dilution step must be included in the test, as described below:

(a) At very high chlorine levels, a pink colour may momentarily appear then disappear when DPD is added to the sample. If the TAC test is done on such a sample the end colour will be yellow not pink. If this is the case then dilute the sample with chlorine-free water and retest;

(b) To measure the amount of sample to dilute, use a graduated test tube, a measuring cylinder or similar accurate measuring vessel. Seek advice if the chlorine level is found to be very high.

H2.2.4.2

The following are important to ensure accurate results when dilution is performed:

(a) Distilled water or clean rainwater should be used for dilution. It is recommended that a small bottle of dilution water be stored in the dark for use when necessary;

(b) Accurately measure the volumes of both dilution water and pool water used in the test. If the comparator tube is not graduated, it will be necessary to measure the volumes using either a measuring cylinder or similar accurate measuring vessel.

H2.2.5 Free available chlorine (FAC) test (with dilution)

Proceed as follows:

(a) Rinse one test tube thoroughly with distilled water;

(b) Either:

(i) Crush a DPD No. 1 tablet (or use equivalent foil-wrapped powder) into the test tube and allow to dissolve in the small amount of distilled water remaining, or

(ii) Add the required amounts of liquid DPD reagents and mix.

(c) Add exactly the amount of dilution water to give the required dilution, place a plastic cap on the test tube and mix by inverting. Do not use bare skin (finger or hand) over the open end of the test tube;

(d) Rinse a second tube thoroughly in pool water and collect a sample normally near the skimmer or scum channel by immersing the tube, open end down, to elbow depth and then turning upright to fill;

(e) Add exactly the required amount of pool water to the test tube containing reagents and dilution water, place a plastic cap on the test tube and mix by inverting several times. Do not use bare skin (finger or hand) over the open end of the test tube;

(f) Immediately compare with colour standards in the comparator;

(g) Note the reading and calculate the FAC concentration in the pool water as follows:

$$\text{FAC (mg/L)} = \frac{\text{Reading x (total volume of dilution water + volume of pool water used)}}{\text{Volume of pool water used}}$$

H2.2.6 Total available chlorine (TAC) test (with dilution)

Proceed as follows:

(a) Either:

  (i) Add a DPD No. 4 tablet (or use equivalent foil-wrapped powder) into a fresh sample of pool water in a clean test tube, or

  (ii) Crush a DPD No. 3 tablet (or use equivalent foil-wrapped powder) into, or add the required amount of potassium iodide powder or solution to the diluted sample just read for FAC;

(b) Mix until dissolved and wait 2 minutes. Do not use bare skin (finger or hand) over the open end of the test tube;

(c) Compare with colour standards in the comparator;

(d) Note the reading and calculate the TAC in the pool water as follows:

$$\text{TAC (mg/L)} = \frac{\text{Reading x (total volume of dilution water + volume of pool water used)}}{\text{Volume of pool water used}}$$

(e) The combined available chlorine is calculated in the same way as for the test without dilution.

H3 Tests for pH

H3.1 Selection of method

A pH meter, correctly used, gives more accurate results than colorimetric kits. However, the pH meter must be calibrated before use. Colorimetric tests may be used to give reliable results where operators are not experienced with meter equipment.

H3.2 pH meter

The pH meter should be operated and maintained in accordance with the manufacturer's instructions. It is preferable that a portable pH meter with built-in temperature compensation be used complete with a robust probe. It is recommended that all aquatic centres and pools with larger volumes use electronic pH meters for pH measurement. Note that a pH meter must be calibrated against appropriate buffer solutions of known strength before use.

H3.3 Colorimetric procedure

H3.3.1

Test kits using phenol red (pH 6.8 – 8.4) are appropriate for the determination of pH in the operational range of 7.4 – 7.6.

Comparator discs must be stored in the dark and should be checked every few years for fading of colours. Replace any faded discs. Ensure that the reagent (indicator) is the correct one for the disc.

It is strongly recommended that test tubes used for pH tests be reserved for this test only and that separate test tubes should be used for chlorine tests. Minute traces of reagents from other tests can cause gross changes in pH readings.

H3.3.2 Procedure

Proceed with the test as follows:

(a) Rinse the test tube several times in the pool;

(b) Collect a sample by immersing the test tube, open end down to elbow depth, and then turning upright to fill to the required level/volume;

(c) Into the test tube add one crystal/required volume of sodium thiosulphate. Close the test tube with a plastic cap or stopper which has been rinsed in the pool and mix to dissolve the thiosulphate. Do not use bare skin (finger or hand) over the open end of the test tube. This step is unnecessary if indicator tablets or a solution incorporating sodium thiosulphate for chlorine neutralisation are used;

(d) Add the required quantity (no more) of indicator and mix as above;

(e) Compare with colour standards in the comparator;

(f) Note and record the pH value shown.

H3.3.3 Interpretation of results

If the reading is at the highest or at the lowest reading on the comparator, the result maybe misleading as the colours will only change within the indicators range. Therefore the actual pool pH may be outside the range covered by the kit and perhaps by a considerable amount. Do not dilute the sample. The pool sample should be retested using a calibrated pH meter. If the water is considerably outside the acceptable pH range, the pool should be immediately closed for urgent remedial action.

H4 Tests for cyanuric acid

H4.1 Test using melamine reagent

Cyanuric acid test kits are available from a variety of manufacturers and therefore the following procedure is general rather than specific to one particular type.

A melamine reagent reacts with cyanuric acid and forms a cloudy suspension in the sample; the more cyanuric acid the more cloudy the sample becomes. The sample should be less than 23°C. Seek expert advice if required.

Proceed with the test as follows:

(a) Rinse the test tube thoroughly in pool water then fill a sample up to the mark;

(b) Place one melamine tablet into the sample under test and allow it to dissolve. The tablet can be crushed to speed up the dissolving process;

(c) Once dissolved the test tube should be capped and mixed by inverting. This process should take at least 5 minutes;

(d) Estimate the concentration of cyanuric acid by following the manufacturer's instructions.

H5 Tests for alkalinity

The most accurate test method is a titration and involves taking an exactly known volume of water, adding an appropriate pH indicator to it (preferably mixed methyl red/bromocresol green) and then adding slowly, with stirring, acid of exactly known strength until the indicator just changes colour. The alkalinity is determined by the volume of acid required. Refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater* for details.

When using test kits, follow the manufacturer's instructions carefully. Remember that the volumes of sample used and any volumes of solution or number of tablets added are to be controlled accurately. All equipment must be chemically clean (distilled or de-ionised water rinsed) and dry.

H6 Tests for chlorides

Chloride tests are required only where electrolytic chlorine generation from salt in the pool is used, or as a management tool for a pool in heavy use.

Operators should seek expert advice for details of test procedures. Refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater*, for details.

H7 Tests for calcium hardness

H7.1 General

Hardness tests provide the following information:

(a) Indication of likely scaling or calcium carbonate precipitation problems such as in pools chlorinated with calcium hypochlorite;

(b) Any leaching of 'hardness' from relatively fresh unpainted concrete surfaces;

(c) Whether water supplies are excessively hard; or

(d) Whether the mineral content of the water requires balancing with the addition of calcium chloride.

In almost all freshwater pools, calcium hardness is the predominant form of hardness and either calcium hardness or total hardness tests may be used to identify the hardness of the water.

H7.2 Hardness tests

The most accurate tests for hardness involve taking a known volume of pool water, adding an appropriate buffer and indicator and then adding slowly, with stirring, EDTA solution of exactly known strength until the indicator just changes colour. The hardness is determined by the volume of EDTA solution required. Refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater* for details. Alternative test methods are available – refer to the manufacturer's instructions.

H8 Tests for total dissolved solids

H8.1 Total dissolved solids

Total dissolved solids (TDS) is a measure of all soluble matter dissolved in water. Mains water often has a TDS of several hundred mg/L. Pool use increases the level of TDS as does the addition of chemicals to a pool, particularly chlorides and sulphates. A high TDS level is an indication of any one or more of the following: excessive pool use, chemical overload, lack of dilution of pool water. The TDS of the pool should be regularly compared with that of the mains water. As a general rule TDS should not rise greater than 1,000 mg/L above the mains water and should not be permitted to rise to an absolute of 3,000 mg/L. TDS is lowered by regularly dumping water and adding fresh (mains supply) water. Diluting the pool at 30 litres per pool user per day is recommended.

TDS is measured with a TDS meter but a conductivity meter can also be used to give an approximate measure of TDS. Typically if the conductivity reading is in units of μmhos/cm or μS/cm, and the meter is calibrated against potassium chloride, the reading is multiplied by 0.65 to give a TDS estimate. If the meter is calibrated against sodium chloride, the reading is multiplied by 0.48 to give a TDS estimate. For meters that read in (mS/m), the respective calculation factors are 4.8 and 6.5. Refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater*, for details.

H8.2 Test for turbidity

The turbidity test measures the suspended particles in a sample that cause loss of clarity by scattering light. This can be used as a useful diagnostic tool for filter performance. The result is measured by nephelometry using a suitably calibrated turbidimeter. Refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater*, and the manufacturer's instructions for details.

H9 Chemical water balance

H9.1 General

The level of the water's total alkalinity, calcium hardness, temperature, and the total dissolved solids can be used to estimate the water's pH of saturation or pHs, the theoretical pH for the pool water to be balanced.

When this pHs is subtracted from the actual pH of the water a numerical value is obtained. A negative number means the water will tend to be corrosive; a positive number and the water will tend to be scale forming. The larger the number the greater the degree of corrosion potential or scale forming potential respectively. Each of the chemical parameters operates interdependently affecting the overall chemistry of the water.

Although the pH, total alkalinity, and calcium hardness of pool water may comply with the levels in tables 2 and 3, the water may still cause scaling or etching of the pool. In order to avoid such problems the water should be chemically balanced.

H9.2 Langelier Index (Saturation Index)

The chemical balance of water is a relationship between its total alkalinity, pH, calcium hardness, temperature, and the total dissolved solids (TDS). One method for determining whether pool water is balanced chemically is to use the version of Langelier's Index shown in figure H1. The Langelier Index, which is based on one from AS 3633 illustrates the relationship between the total alkalinity, pH, and calcium hardness of water. The relationship assumes normal pool conditions in which the water temperature is 27 ± 5 oC and that the total dissolved solids concentration is 1,000 mg/L or less.

Generally the water is considered to be chemically balanced if:

(a) For a cement finished pool for example, Marblesheen, pebbles, plaster, or tiles), the actual pH of the water is within ±0.2 pH units of the pHs determined from the Langelier Index; or

(b) For an inert finished pool (for example, acrylic, epoxy paint, fibreglass, reinforced resin, gel coat, or vinyl lined), the actual pH of the water is LESS than the saturation pH determined from the Langelier Index.

H9.3 Procedure

To ascertain whether the pool water is chemically balanced the procedure shall be as follows:

(a) Determine total alkalinity, pH, and calcium hardness of water as described in H9;

(b) Check that the actual values determined in step (a) are within the limits identified in table 1, and if necessary, adjust by adding the appropriate pool chemical(s) to the water (see H9.6), and repeat step (a);

(c) On the Langelier Index (see figure H1):

  (i) Mark the values obtained in step (a) for total alkalinity and calcium hardness;

  (ii) Draw a straight line joining the marks made in (i);

  (iii) Read off the saturation pH, obtained by the intersection of the straight line in (ii) and the saturation pH axis on the Langelier Index.

Compare the pH values obtained in steps (a) and (c)(iii) to ascertain whether these comply with the relevant criteria in (a) or (b) of H9.2, for chemically balanced pool water:

(d) If the water is not chemically balanced adjust the actual pH or total alkalinity, or both, by adding appropriate pool chemical(s);

(e) Repeat steps (a) to (e) until the water is chemically balanced.

H9.4 Example

The results of an analysis of the water, sanitised by calcium hypochlorite, are as follows:

(a) Total alkalinity = 100;

(b) Calcium hardness = 250;

(c) pH = 7.7.

Plotting the total alkalinity and total hardness on the Langelier Index results in a saturation pH value of 7.5 (see figure H2). That is, the actual pH (7.7) is 0.2 pH greater than the saturation pH (7.5).

If the pool has a cement finish (for example, tiling) then the water would be chemically balanced, as the determination complies with the criteria in H9.2(a). If the pool has an inert finish (for example, vinyl liner) the quality of the water would not be satisfactory as the determination would not comply with the criteria in H9.2(b). To balance the water then, the total alkalinity of the pool should be reduced to about 80 mg/L (see H9.6). This should in turn also reduce the pH of the water to about 7.5 which will result in the water being chemically balanced.

H9.5 Alkalinity/hardness balance

H9.5.1

Where high alkalinity and calcium hardness levels build up, calcium carbonate scales are likely to form, leading to restriction or blockage of filters and pipes, particularly in heat exchangers. Calcium carbonate precipitation may also occur in the pool itself, causing cloudy water. High levels of calcium hardness are more likely to develop in pools where calcium hypochlorite is used for chlorination, or in pools with relatively new unpainted concrete surfaces. Non-calcium based treatment chemicals should be used for treated heated pools to avoid scale build-up in heat exchangers.

H9.5.2

Another way of checking the chemical balance of water is to multiply alkalinity and hardness concentration.

Scale formation or calcium carbonate precipitation varies with pH and temperature and may not occur in many situations even when the alkalinity x hardness product is twice the value in table H1. These values offer only an approximate guide and operating experience will be the deciding factor on appropriate levels.

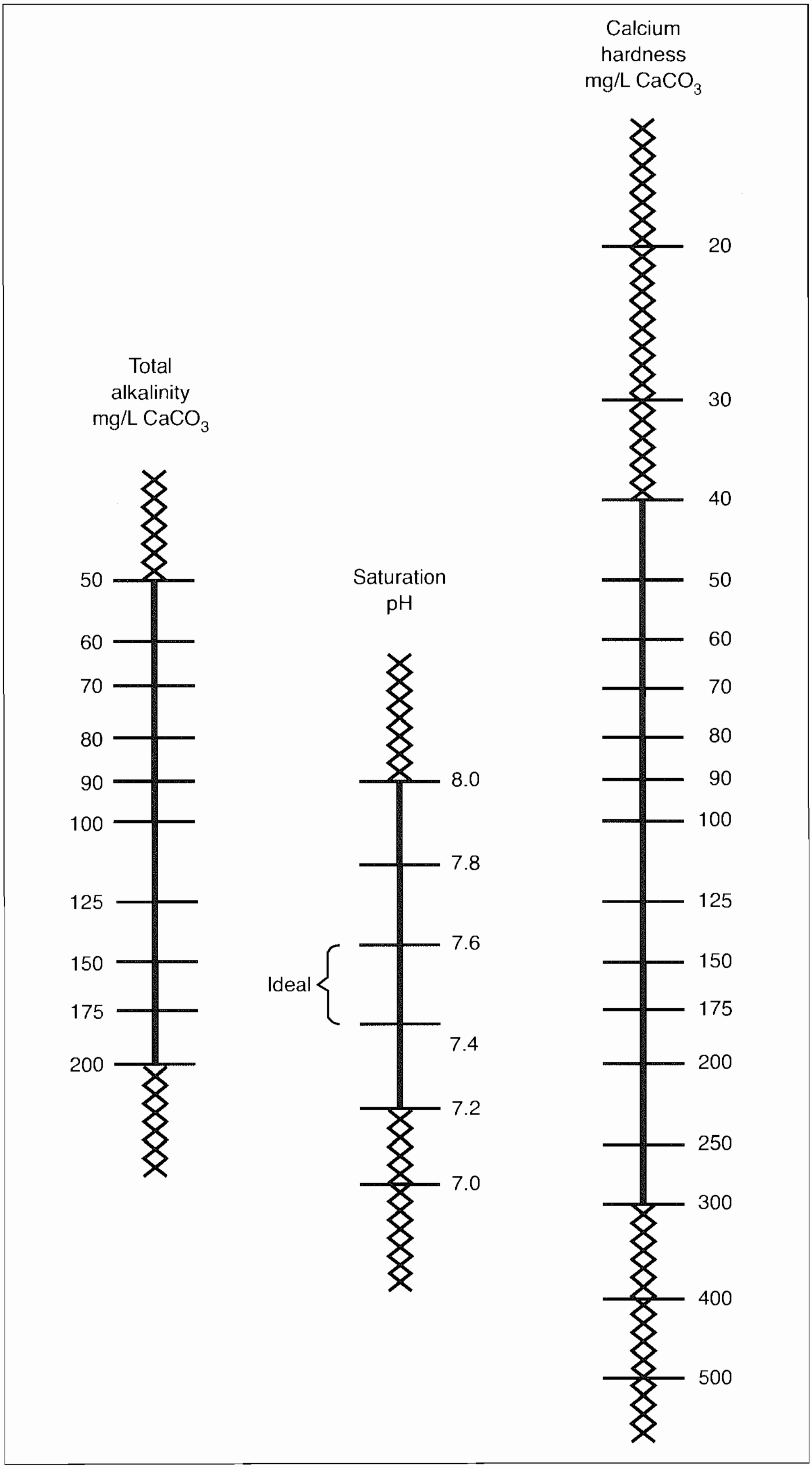


Figure H1 – Watergram for determining the chemical balance of water

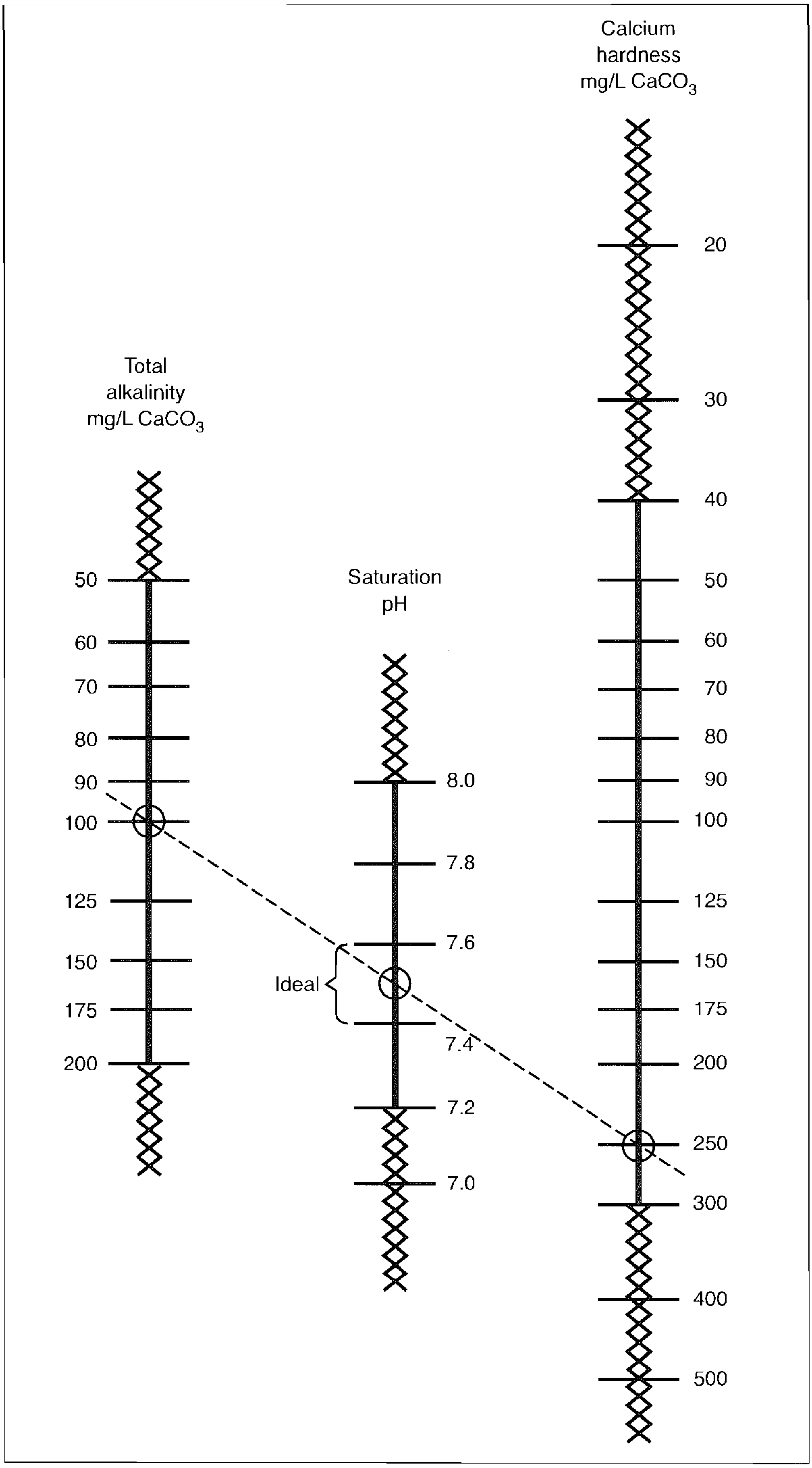


Figure H2 – Watergram for the example calculation in H9.4

Table H1 – Alkalinity x hardness products above which calcium carbonate scaling and precipitation can occur

	Temperature °C			
pH	**20**	**30**	**40**	**50**
8.0	8500	5300	3800	2600
7.8	13000	8500	6000	4200
7.6	21000	13000	9500	6500
7.4	34000	21000	15000	10000

Scale formation is most likely to occur where the pool water temperature is highest, for example, in the heat exchanger. A satisfactory alkalinity x hardness product in pool water may still cause scaling in the heat exchanger.

H9.5.3

The simplest method of overcoming the problem of an excessive alkalinity x hardness product with the availability of a relatively soft water supply is to dump and replace a proportion of water. Alternatively acid may be added to decrease both alkalinity and pH, thereby decreasing alkalinity x hardness product. Where only a very hard water supply is available, special softening treatments may be necessary.

H9.6 Chemicals for pH and alkalinity control

H9.6.1

Alkalinity and pH control chemicals are as follows:

(a) *Sodium bicarbonate* ($NaHCO_3$, also known as *baking soda)*. This increases the alkalinity of pool water without large pH increases. However, the modest pH rise is substantially permanent, so that sodium bicarbonate addition is the preferred pH control procedure in some pools;

(b) *Sodium carbonate* (Na_2CO_3, also known as *soda ash*). This causes large pH increases with modest increases in alkalinity. After the initial pH rise on mixing the sodium carbonate throughout the pool, pH will usually fall again over a period to a level slightly above the original level. Successive sodium carbonate additions will gradually increase alkalinity until a permanent pH rise is achieved. Because of its large effect on pH at normal pool alkalinities, it is not usually suitable for increasing pool alkalinity alone. Sodium carbonate may cause cloudy or milky precipitate to appear when the calcium concentration exceeds to 50 mg/L;

(c) *Sodium hydroxide (NaOH*, also known as *caustic soda)*. It neutralises strong acids or increases the pH. Caustic soda burns skin and should be used only by trained pool operators and usually only where gas chlorination is used. If used, it should be obtained as a liquid only. Check the percentage strength for dosing purposes. Warning: diluting sodium hydroxide produces considerable heat. Add the sodium hydroxide slowly to the required amount of water. Do not add water directly to the sodium hydroxide;

(d) *Dolomitic filter media.* This is used to neutralise acidic water. It is a sacrificial compound, meaning it will ultimately be dissolved as the water acquires the compounds it is lacking. Because of the time delay in this method of neutralisation, exposure of nitrogen compounds to chlorine at a low pH before filtration may cause problems due to the formation of nitrogen trichloride;

(e) *Sodium bisulphate ($NaHSO_4$*, also known as *sodium hydrogen sulphate, sodium acid sulphate*, and *dry acid*). This lowers pH and decreases alkalinity. After the initial fall in pH on mixing the sodium bisulphate throughout the pool, pH will usually rise again over a period to a level slightly below the original level. Successive additions will gradually decrease alkalinity with a consequent decrease in stable pH;

(f) *Hydrochloric acid (HCl*, also known as *spirits of salts*). It lowers pH and decreases alkalinity. Calculations in table H2 are based on commercial grade (35%, 1.18 density) solution. Hydrochloric acid is very corrosive on concrete and metals and on body tissues and therefore should only be used by trained pool operators;

(g) *Calcium chloride.* This is added to increase the calcium content of pool water and reduce corrosiveness (for example leaching from concrete surfaces or grouting) and help stabilise the water. The Langelier or Saturation Index is used to determine the correct amount to add, or consult the supplier for the appropriate dose;

(h) *Carbon dioxide.* This is added to reduce the pH of the water without changing the alkalinity. Typically the use of sodium hypochlorite will cause the pH of pool water to gradually increase, whereas the controlled use of carbon dioxide will counteract this. Available as a compressed gas in cylinders and is applied to water via a venturi system via a regulator.

H9.6.2

Table H2 identifies changes which take place when chemicals described in H9.6.1(a) to (c) and (e) to (f) are added.

Table H2 – Typical changes in pH and alkalinity expected when chemicals are added

Common name	Chemical name	Typical addition	Alkalinity change (as mg/L calcium carbonate)	pH change(1)
Sodium bicarbonate	$NaHCO_3$	50 mg/L	+ 30	+ 0.3
Sodium carbonate	Na_2CO_3	10 mg/L	+ 10	+ 0.3
Sodium hydroxide (2)	NaOH	5 mg/L	+ 6	+ 0.4
Sodium bisulphate	$NaHSO_4$	10 mg/L	– 4	– 0.6
Hydrochloric acid	HCl (35%)	10 ml/L	– 4	– 0.6

NOTE –

(1) The final values are those immediately after full mixing. For all cases except sodium bicarbonate addition, pH will stabilise at a level between the initial and final values.

(2) The strength of the solution should be taken into account when using NaOH solution.

H10 Test for ozone residual

To test for residual ozone refer to the current edition of the APHA publication *Standard methods for the examination of water and wastewater.*

H11 Microbiological sampling

H11.1 Equipment

A sterile sample bottle/container is required.

Sample bottles used for chlorinated or chloraminated water must contain sterile sodium thiosulphate. A sterile aqueous solution of sodium thiosulphate (10% w/v) is generally present in microbiological water sample containers at 1 mL per litre bottle.

NOTE – It is preferable to use plastic rather than glass containers due to the risk from broken glass in a pool area.

H11.2 Routine sampling point for representative pool water quality

The sample is to be representative of the water the pool users can expect to encounter. The most appropriate place to sample from is midway between the water entering the pool from the treatment system and exiting the pool. This sample point should be used for all microbiological sample compliance testing.

H11.3 Investigative sampling point for measuring treatment efficiency

A sample shall be taken from a sampling point prior to the filtration systems and at a sampling point after the filtration system. Points to consider when determining how many samples need to be taken are:

(a) Whether the effectiveness of the overall filtration system is being evaluated or whether the effectiveness of each module is being evaluated;

(b) Whether samples are to include the impact of pH correction, or disinfection chemicals, or both. If this is the case the sample should be taken from a point that allows for chemical mixing (normally 10 x the pipe diameter, or after transition through bends and valves).

H11.4 Label the sample containers

Include the following information:

(a) Date and time of sampling;

(b) Hold the uncapped bottle near its base and quickly plunge it neck-downward below the surface (it is preferable to wear a sterile disposable plastic glove);

(c) Name of sampler.

NOTE – pH, and free available chlorine at the time of sampling should be recorded.

H12 Routine sampling point for chemical characteristics of the pool water

For a sample to be representative of the water the pool users can expect to encounter, the most appropriate place to sample from is midway between the water entering the pool from the treatment system and exiting the pool.

H12.1 Investigative sampling point for measuring treatment efficiency.

A sample shall be taken from a sampling point prior to the filtration systems and at a sampling point after the filtration system. Points to consider when determining how many samples need to be taken.

(a) Whether the effectiveness of the overall filtration system is being evaluated or whether the effectiveness of each module is being evaluated;

(b) Whether samples are to include the impact of pH correction and or disinfection chemicals. If this is the case the sample should be taken from a point that allows for chemical mixing (normally 10 x the pipe diameter or after transition through bends and valves).

12.2 Sample collection

For the in pool sample fill the bottle, leaving no headspace:

(a) Remove the lid, taking care not to contaminate the inside of the lid or the open neck of the bottle;

(b) For the in-pool sample hold the uncapped bottle near its base and plunge it neck-downward below the surface;

(c) Turn the bottle so its neck points slightly upward and create a current artificially by moving the bottle forwards (so water from the hand does not enter the bottle). Fill the bottle to overflowing and gently screw on the top.

For collecting from a tap sample point:

(d) Allow the sample tap to flow for at least 30 seconds.

(e) Fill the bottle to overflowing and gently screw on the cap.

H12.3 Label the sample containers

Include the following information:

(a) Date and time of sampling;

(b) Sample details (name of pool/site code/sample point);

(c) Name of sampler.

NOTE – pH and free available chlorine at the time of sampling should be recorded as soon as possible.

H12.4 Sample transport

Ensure the lids of the sample bottles are screwed tight and place bottles upright for transportation to the laboratory.

For an external laboratory complete the required documentation.

For the in-house laboratory ensure data is recorded on the appropriate water quality data sheets and that the reason for sampling is recorded.

H13 Results sheet

Maintenance of accurate and complete records is essential to ensure good pool management procedures and full sampling and testing records are to be kept. See figure H3 for an example. Pool facilities will need to customise their water test sheets to meet their specific requirements.

Date						
Name of pool						
Daily test/observation	FAC and pH – Prior to daily use then every 3 hours *NZS 5826:2010 – Minimum frequency of chemical testing for swimming pools					
Sample time	6.00am	9.00am	12.00 noon	3.00pm	6.00pm	9.00pm
TAC (mg/L)						
FAC (mg/L)						
CAC (mg/L) *Recommended <0.5 mg/L*						
pH						
People in pool						
General (flow, weather, temperature)						
Name of tester						

Weekly test/observation			Recommended Standard (NZS 5826:2010)	
Alkalinity (mg/L as $CaCO_3$)			FAC (chlorine alone)	1.5 – 7.0 mg/L *preferably 2.5 – 5.0 mg/L*
Cyanuric acid (as required) (mg/L)			FAC (chlorine + other)	0.5 – 5.0 mg/L *preferably 1.0 – 2.5 mg/L*
Chloride (as required) (mg/L)			pH	7.2 – 8.0 *preferably 7.4 – 7.6*
TDS Recommended <1000 mg/L above make-up (mg/L)			Alkalinity (acidic disinfectants)	100 – 200 mg/L *preferably 120 – 150 mg/L*
			Alkalinity (alkaline disinfectants)	50 – 200 mg/L *preferably 60 – 120 mg/L*
			Cyanuric acid	25 – 100 mg/L *preferably 30 – 60 mg/L*

Monthly test/observation	
Calcium hardness (mg/L as CaCO3)	
Microbiological (Laboratory results attached?)	

Faecal/vomit incident	Time & description of action taken	Actioned by

Name of person who filled in this sheet:

Figure H3 – An example of a swimming pool water test sheet

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APPENDIX J – TROUBLESHOOTING

(Informative)

J1 Pool management troubleshooting

Table J1 will assist in the identification and resolution of various problems likely to be encountered in pool management.

Table J1 – Troubleshooting

Problem	Cause	Solution/suggestion
Swimmers complain of sore eyes	Check pH, may be due to chloramines	If pH below 7.2 or above 8.0 adjust pH to desirable levels Superchlorinate overnight (10 mg/L FAC) Check that chlorine level is between 2.0 and 5.0 mg/L FAC before swimming is allowed Lower TDS by refreshing with make-up water A persistent problem may be due to nitrogen trichloride Raise pH to 7.5 and allow chlorine to fall to zero. Then superchlorinate Seek advice before using alternative oxidant
Swimmers complain of grit in their eyes	Check undissolved cyanuric acid	Tow a bucket around the pool to mix and aid dissolving. Suction/vacuum clean
Swimmers complain of sore ears	Microbiological	Superchlorinate (see note). Next morning check chlorine level before permitting pool use
Swimmers complain of skin rashes	Microbiological water chemistry Superchlorinate	Sensitivity to chlorine and its compounds
Pool smells of chlorine	Check CAC levels	Superchlorinate. Consider dilution with make-up water Ensure an adequate FAC concentration is maintained Reduce the bathing load in the pool Dump pool water and make up with fresh Ensure sufficient make-up water is introduced into the pool (ca.30 L/person/day)
Pool smells musty	May be due to algal growth	Superchlorinate
Pool turns green	May be lack of chlorine, or incorrect pH	Superchlorinate. If problem persists, seek advice
Pool turns green/cloudy. Poor chlorine efficacy. Pool water looks dull and flat	High TDS reading (does not apply to salt chlorinated pools)	Reduce by diluting, that is, drain off one-third to half the pool volume and replace with make-up water – or seek further advice
pH falls below 7.2	–	Raise the pH by the addition of sodium bicarbonate (see table H2)

Table J1 – Troubleshooting (continued)

pH persistently low and unstable	Low alkalinity	Add sodium bicarbonate
pH rises above 8.0	–	If using hypochlorites or electrolytic chlorination, lower pH with sodium bisulphate (see table H2), or dilute the pool with make-up water, or backwash the sand filters for an extended period
Alkalinity too low	–	Raise alkalinity by the addition of sodium bicarbonate (see table H2)
Alkalinity too high	–	If alkalinity becomes too high to satisfactorily hold pH below 8.0, most or all of the pool water should be dumped and fresh water added. Alternatively, adding sodium bisulphate at 50 mg/L of pool volume will decrease the alkalinity by 20 mg/L as CaCO3. To avoid short-term excessively low pH values, no more than 20% of the pool alkalinity should be removed on any one day by chemical addition. Decreasing alkalinity with hydrochloric acid should only be attempted by trained pool operators
NOTE – If you are going to take any microbiological samples following complaint, do so before superchlorination.		

J2 Control of algal and slime growth

J2.1 General

If free chlorine levels are adequate at all times, algal and slime growths should not develop or will be of minor concern. If more extensive and troublesome growths occur, special cleaning procedures, super chlorination or the addition of specifically formulated algicides may be necessary to remove and control them. Copper sulphate not be used in pools because insoluble copper carbonate may precipitate in the pool and clog filters. Copper sulphate may also turn blonde hair green.

J2.2 Resistant growths

When pool surfaces are affected by persistent growths, superchlorinate. If operated in a high pH regime (for example, 7.8 or above) lower the pH to below 7.6 before superchlorinating. Leave the pool to stand overnight then brush affected areas. Vacuum any debris from the pool floor to waste. Readjust pH and chlorine. Repeat if necessary.

J2.3 Algaecide types

The simplest algaecides are stand-alone agents such as chlorine or hydrogen peroxide. Several proprietary brand algaecides are available. These may, or may not, be compatible with chlorine. Information on chlorine compatibility will be contained in the materials safety data sheet for the product, or from supplier product information.

The concentration of algaecides should be taken from supplier recommendations. Algaecide types may need to be varied from season to season.

APPENDIX K – ESTIMATING RISK

(Informative)

K1 General

The levels of risk noted in the risk information tables of the guides in Part 2 are considered typical, and provide an indicative guide only. It is not possible to provide an estimate of risk that will apply to all pools, because the factors affecting the level of risk are likely to be different for each pool.

This appendix offers guidance on estimating qualitative risk, if the pool manager would prefer to estimate the level of risk for their pool themselves. Documents which will provide information and guidance in this process are AS/NZS ISO 31000 *Risk management – Principles and guidelines* providing fundamental principles and guidelines, and ISO/IEC 31010 *Risk management – Risk assessment* techniques, a supporting Standard providing significant additional information and guidance on the selection and application of various systematic techniques for risk assessment.

Figure K1 shows the process involved in assessing risk. In all instances the risk management process should be tailored to the requirements of the pool owner, to enhance and support existing procedures.

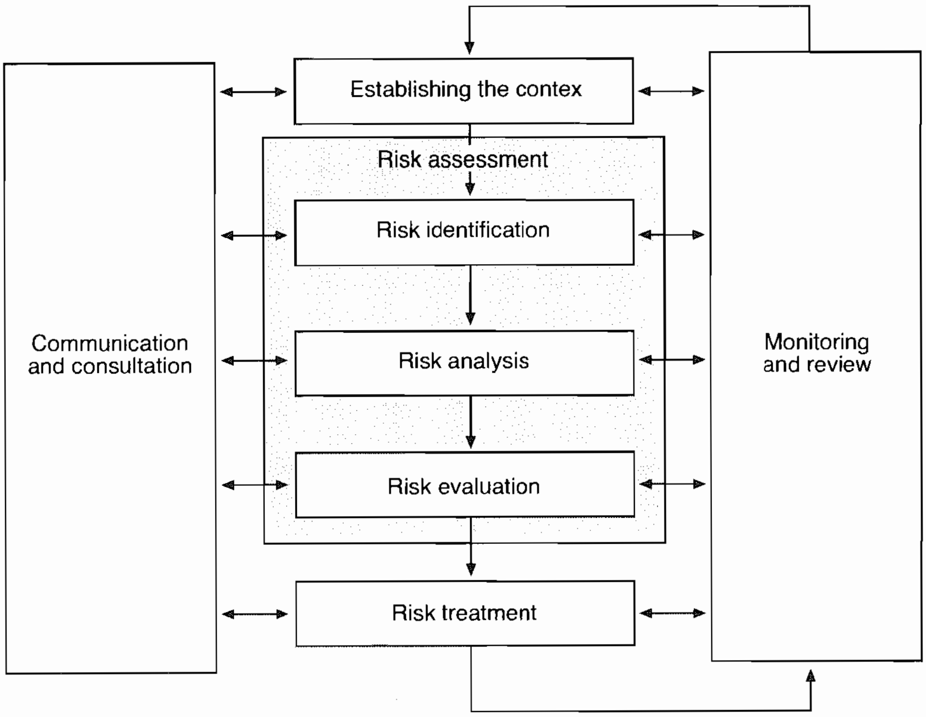

Figure K1 – Risk management process

K2 Consequence and probability matrix

One approach to managing pool risk is the 'consequence and probability matrix' technique which is used to rank risks, sources of risk, or risk treatments based on the level of risk. This technique is commonly helpful as a screening tool when many risks have been identified. Inputs to the process are customised scales for consequence and probability, and a matrix which combines the two. The level of risk associated with a particular event is calculated based on the likelihood of the event occurring, and the consequences (or outcome) of it occurring. Factors affecting the consequence include the number of people that may be affected, the duration of the event, the severity of the event (this would depend on the hazard introduced into the water by the event).

Table K1 is an example of a possible risk likelihood scale and table K2 shows a possible consequence criteria scale. These may be helpful to those using this Standard for pool water risk assessments. Users may alternatively generate their own scales.

Table K1 – Risk likelihood ranking scale

Likelihood ranking	Description
Rare	May occur only in exceptional circumstances (once in 1000 years)
Unlikely	Could occur (once in 100 years)
Possible	Might occur at some time (once in 10 years)
Likely	Will probably occur (once in 1 or 2 years)
Almost certain	Is expected to occur in most circumstances

Table K2 – Consequence criteria scale

Consequence ranking	Description
Insignificant	Insignificant
Minor	Minor impact for pool users, for example bather discomfort
Moderate	Minor impact for local community, for example bad publicity regarding pool water quality
Major	Major impact for pool users, for example bather health affected
Catastrophic	Major impact for local community, for example public outcry/public health adversely affected

A typical probability criteria matrix, using ranking and consequence criteria, is shown in table K3.

Table K3 – Example of a probability criteria matrix

Likelihood	**Consequence rating**				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	High	High	Extreme	Extreme	Extreme
Likely	Moderate	High	High	Extreme	Extreme
Possible	Low	Moderate	High	Extreme	Extreme
Unlikely	Low	Low	Moderate	High	Extreme
Rare	Low	Low	Moderate	High	High

Similar to table K3, tables K4 and K5 are examples of grading risk. The tables provide a list of recommended actions based on the consequences or level of seriousness.

Table K4 – Example of a risk ranking matrix

Recommended actions for grades of risk	
Grade	**Risk actions**
A	Actions to reduce the likelihood and seriousness to be identified and implemented as a matter of urgency.
B	Actions to reduce the likelihood and seriousness to be identified and appropriate actions implemented as soon as possible.
C	Actions to reduce the likelihood and seriousness to be identified and costed for possible action if funds permit.
D	To be noted – no action is needed unless grading increases over time.
E	To be noted – no action is needed unless grading increases over time.

Table K5 – Example of a probability criteria matrix using risk ranking

Grades of risk: Combined effect of likelihood or seriousness					
	Seriousness				
		Low	Medium	High	Extreme
Likelihood	Low	E	D	C	A
	Medium	D	C	B	A
	High	C	B	A	A

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